JOURNAL

OF THE

New England Water Works Association.

VOLUME XVI.

1902.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION.

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NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVI. March, 1902. No. 1.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

CONSTITUTION OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

[*Adopted September 19, 1900.*]

ARTICLE I.

NAME AND OBJECT.

SECTION 1. The name of this society shall be THE NEW ENGLAND WATER WORKS ASSOCIATION.

SECT. 2. Its objects shall be the advancement of knowledge relating to water works and water supply, and the encouragement of social intercourse among water works men.

ARTICLE II.

SECTION 1. The membership of the Association shall consist of Members, Honorary Members, and Associates.

SECT. 2. Water works superintendents or other executive officers, commissioners or members of Water Boards, hydraulic engineers, sanitarians or other persons qualified to aid in the advancement of knowledge relating to hydraulic questions, shall be eligible as Members.

SECT. 3. Members only shall be eligible to office and entitled to the right to vote.

SECT. 4. Associates shall be firms or representatives of firms engaged in dealing in supplies used by water works.

SECT. 5. Members hereafter elected engaging in the business of furnishing water works supplies shall cease to be Members of the Association and their names shall be transferred to the list of Associates.

SECT. 6. Associates shall be entitled to representation at each meeting of the Association, but shall not be entitled to vote or to take part in any discussion unless permission is given by the meeting.

SECT. 7. Honorary Members shall be men eminent in some line of work connected with hydraulic engineering or water supply.

SECT. 8. Members shall be classed as Resident or Non-Resident; the

former comprising residents of the New England States, all others being Non-Resident Members.

ARTICLE III.

ADMISSIONS AND EXPULSIONS.

SECTION 1. An application for admission to the Association as Member or Associate shall embody a concise statement of the candidate's qualifications for membership, and shall be endorsed by two Members of the Association.

SECT. 2. Applications for membership shall be considered by the Executive Committee, who shall present them to the Association for ballot, provided a majority are in favor of such action.

SECT. 3. Election to membership shall be by ballot, and shall require two thirds of the ballots cast.

SECT. 4. Members and Associates elect shall subscribe their names to the Constitution by signing a form to be furnished by the Secretary.

SECT. 5. Any person who shall be in arrears to the Association for two years' dues shall be notified by the Secretary that if payment is not made within three months his name will be dropped from the roll; and if such arrears are not paid within the time specified, the Secretary shall erase the name from the membership list.

SECT. 6. A member of any grade may withdraw from the Association by giving written notice to the Secretary and settling all indebtedness to the Association.

SECT. 7. A member of any grade may be expelled from the Association upon the recommendation of the Executive Committee, adopted by a two-thirds vote of the members present and voting at any regular meeting.

ARTICLE IV.

DUES.

SECTION 1. The Initiation Fee shall be—

For Resident Members	$5.00
For Non-Resident Members	3.00
For Associates	10.00

SECT. 2. The Annual Dues shall be—

For Members	$3.00
For Associates	15.00

which shall include a subscription to THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

SECT. 3. A person transferred from the grade of Member to that of Associate shall not be assessed an additional initiation fee, but shall be liable for dues as an Associate.

ARTICLE V.

OFFICERS.

SECTION 1. The officers of this Association shall be a President, six Vice-Presidents, not more than three of whom shall be residents of the same State, a Secretary, and a Treasurer; these, together with the Editor and Advertising Agent of THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION and three other Members, shall constitute the Executive Committee, in whom the government of the Association shall be vested.

SECT. 2. The term of office of all officers and committees shall be one year, but shall continue until their successors are duly elected.

SECT. 3. There shall also be a Finance Committee of three Members of the Association other than members of the Executive Committee.

SECT. 4. All officers and committees shall assume their duties immediately after the close of the meeting at which they have been elected.

ARTICLE VI.

DUTIES OF OFFICERS.

SECTION 1. The President shall have a general supervision of the affairs of the Association. He shall preside at meetings of the Association and of the Executive Committee. In case of his absence or a vacancy in his office, the Vice-Presidents in order of seniority shall discharge his duties.

SECT. 2. The Executive Committee shall have full control of the management of the Association, subject to the action of the Association at any meeting. They shall make the necessary arrangements for all meetings, and shall have power to expend the funds of the Association, provided that no indebtedness shall be incurred in excess of the funds in the hands of the Treasurer. All questions in Executive Committee shall be decided by a majority vote, and six members shall be a quorum. The Executive Committee shall hold meetings at the call of the President, or, in his absence or inability to serve, at the call of the senior Vice-President.

SECT. 3. The Secretary shall conduct the official correspondence of the Association, shall collect and receipt for all fees and dues, and transmit the same to the Treasurer quarterly, taking his receipt therefor; he shall issue notices of all meetings of the Association at a date not less than two weeks prior to the time appointed for such meetings. He shall make a report to the Association at the annual meeting of the general condition of the Association and especially of changes in the membership.

SECT. 4. The Treasurer shall receive from the Secretary all moneys collected by him for the Association, giving his receipt therefor, and shall pay all demands against the Association when approved by the President. He shall keep a proper account of all receipts and expenditures, and shall make a report to the Association, at the annual meeting, of his doings as

Treasurer during the year preceding, together with a statement of the financial standing of the Association.

SECT. 5. The Finance Committee shall meet on or before the day of the annual meeting, and shall audit the accounts of the Secretary and Treasurer. They shall hold such other meetings as the interests of the Association may require.

SECT. 6. The proceedings of the Association shall be published as THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, which shall be issued quarterly, under the direction of a Board of Editors, consisting of the President and Secretary, *ex officiis*, and the Editor and Advertising Agent chosen by ballot. The Journal shall contain such portion of the record of any meeting as the Board of Editors may deem it expedient to publish, as well as any other articles which they shall consider of interest to the Association.

SECT. 7. The Editor of THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION shall, under the direction of the Board of Editors, keep and prepare for publication all matters intended to be printed in the Journal, and shall act as the executive officer of the Board of Editors. He shall present a report at the annual meeting, showing in detail the cost of publication of the Journal and the receipts from advertising and subscriptions.

ARTICLE VII.

NOMINATION AND ELECTION OF OFFICERS.

SECTION 1. At the business meeting during the annual convention the Association shall elect or appoint, in such manner as may be approved by the meeting, a Nominating Committee of five members, who shall present a report before the first day of November, in the form of a list of nominations for officers for the ensuing year. This report shall be printed and mailed by the Secretary to the membership of the Association.

SECT. 2. At any time before December 1, any ten or more Members of the Association may send to the Secretary additional nominations signed by such Members.

SECT. 3. The Secretary shall issue a printed ballot on the fifteenth day of December, which shall contain the nominations made by the Nominating Committee and such other nominations as may have been received by him in accordance with Section 2. This ballot shall be mailed to all members entitled to vote.

SECT. 4. Ballots may be sent by mail to the Secretary or handed to him directly. They must be enclosed in two sealed envelopes, and the outer envelope shall be endorsed by the voter's signature.

SECT. 5. The polls shall be closed one hour after the time of opening the Annual Meeting, and the ballots shall be canvassed by tellers appointed by the presiding officer. The persons receiving the highest number of votes for the offices for which they are candidates shall be declared elected.

ARTICLE VIII.

MEETINGS.

SECTION 1. A Convention of the Association for the reading and discussion of papers and for social intercourse shall be held annually at such time and place as may be determined by the Executive Committee.

SECT. 2. There shall be two general business meetings of the Association each year; first, the annual meeting, which shall be held in Boston on the second Wednesday in January, and at which the annual reports for the year ending December 31 shall be presented, and the ballot for officers canvassed; and second, a business meeting during the annual convention.

SECT. 3. In addition to the above, business meetings shall be held on the second Wednesday of the months of November, December, February, and March, and, at the discretion of the Executive Committee, in June.

SECT. 4. At any business meeting of the Association, twenty members shall constitute a quorum.

SECT. 5. All regular meetings of the Association, except the annual convention, shall be held in Boston, unless otherwise voted by the Executive Committee.

SECT. 6. Special meetings of the Association may be held at the call of the President. At special meetings no applications for membership shall be considered, and no business shall be transacted unless announced in the call for the meeting and on the recommendation of the Executive Committee.

SECT. 7. Meetings of the Executive Committee shall be held before each business meeting of the Association and at such other times as the President may deem necessary.

ARTICLE IX.

AMENDMENTS.

SECTION 1. Proposed amendments to this Constitution must be submitted in writing to the Executive Committee, and shall be presented to the Association at a regular meeting, if so decided by vote of the committee. It shall be the duty of the Executive Committee to bring before the Association any proposed amendment at the written request of ten Members.

SECT. 2. Announcements of a proposed amendment which is recommended by the Executive Committee, or by ten Members of the Association, shall be given by printing the amendment in the notices of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of an amendment.

OFFICERS

OF THE

New England Water Works Association.

1902.

PRESIDENT.

FRANK E. MERRILL.

VICE-PRESIDENTS.

CHARLES K. WALKER.
JAMES BURNIE.
EDWIN C. BROOKS.
H. O. SMITH.
WILLIAM B. SHERMAN.
J. C. HAMMOND, JR.

SECRETARY.

WILLARD KENT.

TREASURER.

LEWIS M. BANCROFT.

EDITOR.

CHARLES W. SHERMAN.

ADVERTISING AGENT.

ROBERT J. THOMAS.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

PATRICK KIERAN.
GEORGE A. STACY.
HORACE G. HOLDEN.

FINANCE COMMITTEE.

A. W. F. BROWN.
WILLIAM F. CODD.
J. W. CRAWFORD.

PAST PRESIDENTS.

*JAMES W. LYON, 1882–83.
FRANK E. HALL, 1883–84.
GEORGE A. ELLIS, 1884–85.
ROBERT C. P. COGGESHALL, 1885–86.
*HENRY W. ROGERS, 1886–87.
*EDWIN DARLING, 1887–88.
*HIRAM NEVONS, 1888–89.
DEXTER BRACKETT, 1889–90.
*ALBERT F. NOYES, 1890–91.
HORACE G. HOLDEN, 1891–92.
GEORGE F. CHACE, 1892–93.
*GEORGE E. BATCHELDER, 1893–94.
GEORGE A. STACY, 1894–95.
DESMOND FITZGERALD, 1895–96.
*JOHN C. HASKELL, 1896–97.
WILLARD KENT, 1897–98.
FAYETTE F. FORBES, 1898–99.
BYRON I. COOK, 1899–1900.
FRANK H. CRANDALL, 1901.

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* Deceased.

LIST OF MEMBERS,

WITH ADDRESS AND DATE OF ELECTION.

[*Corrected to February 1, 1902.*]

NAME.	Date of Election.
Adams, John D. Supt. Water Works, Provincetown, Mass.	Sept. 8, 1897
Allen, Charles A., C. E. 44 Front Street, Rooms 109, 110, Worcester, Mass.	June 16, 1886
Allen, Charles F. Treasurer Water Co., Hyde Park, Mass.	June 16, 1886
Amyot, John A., M. B. Bacteriologist to the Provincial Board of Health of Ontario, 306 Joseph Street, Toronto, Canada.	Nov. 14, 1900
Anderson, J. M. 246 Pleasant Street, Worcester, Mass.	Jan. 9, 1901
Andrews, Frank A. Assistant Supt. Pennichuck Water Works, Nashua, N. H.	Dec. 14, 1887
Anthony, Charles, Jr. Casilla 1045, Buenos Aires, South America.	June 12, 1901
Appleton, Francis E. Paymaster Locks & Canals Co., Lowell, Mass.	Dec. 8, 1897
Armstrong, S. G., C. E. 1 Kimberly Villa, Harrington Street, Cape Town, South Africa.	Feb. 13, 1895
Babcock, Stephen E. Water Works and Hydraulic Engineer, Little Falls, N. Y.	June 12, 1886
Bacot, R. C., Jr. Supt. Meter Dept., P. O. Box 221, Port Chester, N. Y.	Dec. 12, 1888
Badger, Frank S. 28 Bellevue Street, Lowell, Mass.	June 10, 1896
Bagnell, Richard W. Plymouth, Mass.	Dec. 21, 1882
Bailey, E. W. City Engineer, Somerville, Mass.	Dec. 11, 1895
Bailey, Frank S. State Board of Health, State House, Boston, Mass.	Sept. 8, 1897
Bailey, George I. Consulting Engineer, 51 State Street, Albany, N. Y.	Dec. 14, 1892
Baker, M. N. Associate Editor "Engineering News," 220 Broadway, New York City.	Sept. 18, 1901
Baldwin, Charles H. 159 Franklin Street, Boston, Mass.	June 17, 1887
Bancroft, Lewis M. Supt. Water Works, Reading, Mass.	Jan. 8, 1890
Barbour, Frank A., C. E. 1120 Tremont Building, Boston, Mass.	Jan. 10, 1894

Name.	Date of Election.
Barnes, Roland D., C. E. 23 Spring Street, Malden, Mass.	June 14, 1899
Barrus, George H. Consulting Steam Engineer, 12-20 Pemberton Building, Pemberton Square, Boston, Mass.	Jan. 14, 1891
Bartlett, Charles H., C. E. 607 Pemberton Building, Boston, Mass.	Feb. 8, 1893
Bartlett, R. S. Supt. Water Works, Norwich, Conn.	Jan. 13, 1897
Bassett, Carroll Ph. Treasurer Water Co., Summit, N. J.	June 13, 1889
Bassett, George B., C. E. 363 Washington Street, Buffalo, N. Y.	Sept. 10, 1897
Batchelder, George W. Water Registrar, Worcester, Mass.	June 14, 1899
Batcheller, Francis Water Commissioner, North Brookfield, Mass.	Jan. 10, 1894
Bates, Oren B. Clinton, Mass.	Sept. 11, 1895
Bates, Hon. Theodore C. 29 Harvard Street, Worcester, Mass.	Jan. 10, 1894
Beals, Joseph E. Supt. Water Works, Middleboro, Mass.	June 16, 1886
Beardsley, Joseph C. 2d Asst. Engr. Cleveland Water Works, Cleveland, Ohio.	Sept. 18, 1901
Beasom, C. B., C. E. 248 Tremont Street, Newton, Mass.	Dec. 12, 1894
Bemis, Edward W. Supt. Water Works, Cleveland, Ohio.	Nov. 13, 1901
Bennett, Thomas H. Supt. Water Works, Oswego, N. Y.	March 14, 1900
Benzenberg, G. H. Milwaukee, Wis.	June 9, 1892
Berkey, John A. President Electric and Water Co., Little Falls, Minn.	Feb. 8, 1893
Bettes, Charles R. Chief Engineer, Queen's County Water Co., Far Rockaway, N. Y.	Dec. 9, 1896
Betton, James M. 10 East 16th Street, New York City.	Jan. 8, 1902
Bigelow, James F. City Engineer, Marlboro, Mass.	Sept. 11, 1895
Birkinbine, Henry Hydraulic Engineer, 124 East Market Street, York, Pa.	June 17, 1887
Bisbee, Forrest E. Supt. Water Works, Auburn, Me.	Sept. 11, 1895
Bishop, George H., C. E. 129 Main Street, Middletown, Conn.	June 16, 1886
Bishop, Watson L. Supt. Water Works, Dartmouth, N. S.	March 8, 1893
Blackmer, James W. Supt. Water Works, Beverly, Mass.	March 8, 1899

NAME.	Date of Election.
Blossom, William L., C. E. 855 Washington Street, Brookline, Mass.	Dec. 13, 1893
Boggs, Edward M. Consulting Civil and Hydraulic Engineer, 534 Stimpson Block, Los Angeles, Cal.	Dec. 11, 1889
Bowers, George City Engineer, Lowell, Mass.	March 9, 1892
Boyer, Francis H. 13 Highland Avenue, Somerville, Mass.	June 12, 1901
Brackett, Dexter Engineer Distribution Dept., Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	April 21, 1885
Bradley, R. H. Supt. Water Works, LeSueur, Minn.	Dec. 14, 1892
Brinsmade, Daniel S. President and Engineer Ousatonic Water Co., Birmingham, Conn.	Sept. 19, 1883
Broatch, J. C. Supt. Water Works, Middletown, Conn.	April 21, 1885
Brooks, Edwin C. Supt. Water Works, Cambridge, Mass.	Feb. 10, 1897
Brooks, Fred 31 Milk Street, Boston, Mass.	Feb. 8, 1899
Brown, A. W. F. Water Registrar, Fitchburg, Mass.	June 17, 1887
Brown, J. Henry 3 Tremont Street, Charlestown, Mass.	Sept. 19, 1883
Brown, Walter I. Water Registrar, Bangor, Me.	June 11, 1896
Brownell, Ernest H., C. E. Brownell Block, 107 Westminster Street, Providence, R. I.	Jan. 11, 1893
Bucknam, George A. P. Supt. Water Works, Norwood, Mass.	June 10, 1891
Burke, James E. Sec'y, Treas., and Supt. Princeton Water Co., Princeton, N. J.	Sept. 11, 1895
Burley, Harry B. 31 Milk Street, Room 55, Boston, Mass.	Dec. 14, 1892
Burnham, Albert S. Supt. Water Co., Revere, Mass.	June 13, 1888
Burnie, James Supt. Water Co., Biddeford, Me.	June 11, 1890
Burns, Clinton S. 409 Postal-Telegraph Building, Kansas City, Mo.	Dec. 12, 1900
Burr, William H. Professor of Civil Engineering, Columbia University, and Consulting Engineer, New York City.	Feb. 16, 1894
Burse, A. H. Supt. Water Works, Pittsfield, Me.	Sept. 16, 1898
Bush, Edward W., C. E. Ætna Life Building, Hartford, Conn.	Feb. 13, 1895
Butler, J. Allen Supt. Portland Water Co., Portland, Conn.	June 10, 1891

Name.	Date of Election.
Cairns, R. A. City Engineer, Waterbury, Conn.	Feb. 13, 1895
Card, Huber D. City Engineer, Willimantic, Conn.	Jan. 8, 1896
Carpenter, L. Z. Attleboro, Mass.	Dec. 13, 1899
Carroll, Fred B. Rumford Falls, Me.	Dec. 12, 1888
Cassell, George Supt. Water Works, Chelsea, Mass.	March 8, 1899
Caulfield, John Sec'y Water Works, St. Paul, Minn.	Dec. 8, 1897
Cavanagh, John T. Quincy, Mass.	Feb. 8, 1893
Chace, George F. Supt. Water Works, Taunton, Mass.	June 13, 1888
Chadbourne, E. J. Supt. Water Co., Wakefield, Mass.	June 18, 1885
Chandler, Charles E. City Engineer, 161 Main Street, Norwich, Conn.	June 17, 1887
Chandler, Prof. Charles F. 51 East 54th Street, New York City.	Dec. 12, 1888
Chapin, G. L. Water Commissioner, Lincoln, Mass.	March 10, 1897
Chapman, Benjamin R. Asst. Engineer, Brockton, Mass.	Feb. 9, 1898
Chase, John C. Chief Engineer Water Works Co., Derry, N. H.	June 19, 1884
Clapp, Sidney K. Waterbury, Conn.	Jan. 10, 1900
Clapton, William Supt. Water Co., Newtown, N. Y.	Sept. 11, 1895
Clark, D. W. President Water Co., Portland, Me.	June 12, 1890
Clark, Frederick W. Clerk Chestnut Hill Reservoir, Metropolitan Water Works, Brighton, Mass.	Jan. 11, 1893
Clark, Harry W. Chemist, Mass. State Board of Health, State House, Boston, Mass.	March 14, 1894
Clark, S. Frederic Water Commissioner, North Billerica, Mass.	March 8, 1899
Clarke, E. W. Asst. Engineer, Rapid Transit R. R. Commission, 13 Astor Place, New York City.	Jan. 10, 1894
Cleveland, W. F. Sewer Commissioner, Brockton, Mass.	June 9, 1892
Cochran, Robert L. Supt. Water Works, Nahant, Mass.	June 16, 1886
Codd, William F. Supt. Wannacomet Water Co., Nantucket, Mass.	June 21, 1885

NAME.	Date of Election
Coffin, Freeman C. Civil and Hydraulic Engineer, 58 State Street, Boston, Mass.	Feb. 13, 1889
Coggeshall, R. C. P. Supt. Water Works, New Bedford, Mass.	June 21, 1882
Cole, D. W. Box 696, Thomaston, Conn.	March 14, 1900
Cole, F. M. Meter Inspector, Brockton Water Works, Brockton, Mass.	Feb. 10, 1897
Collins, Lewis P. Lawrence, Mass.	Dec. 12, 1894
Collins, Michael F. Supt. Water Works, Lawrence, Mass.	Sept. 18, 1901
Colson, Charles D. Water Commissioner, Holyoke, Mass.	March 9, 1898
Connell, Michael A. Supt. Water Works, St. Hyacinthe, P. Q.	Dec. 13, 1893
Cook, Byron I. Woonsocket, R. I.	March 13, 1889
Cook, Henry A. Supt. Water Works, Salem, Mass.	Feb. 10, 1892
Crandall, F. H. Supt. and Treas. Water Works, Burlington, Vt.	June 13, 1888
Crandall, George K. Civil Engineer, New London, Conn.	June 9, 1892
Crawford, J. W. Clerk of Water Board, Lowell, Mass.	June 12, 1896
Croes, J. J. R., C. E. 68 Broad Street, Morris Building, New York City.	June 17, 1887
Crosby, Everett U. 54 William Street, New York City.	March 4, 1900
Crowell, George E. President Water Works, Brattleboro, Vt.	June 15, 1893
Cuddeback, Allan W. Asst. Engineer Passaic Water Co., 109 Washington Street, Paterson, N. J.	Jan. 10, 1900
Curtis, George D. 75 Tonawanda Street, Dorchester, Mass.	Sept. 19, 1900
Cushing, Lucas Box 108, Mansfield, Mass.	Dec. 12, 1888
Daboll, L. E., C. E. New London, Conn.	Jan. 10, 1894
Danforth, John L. Gen. Supt. Spring Water Co., Kane, Pa.	Sept. 10, 1897
Davenport, Dr. B. F. Chairman Water Board, Watertown, Mass.	Feb. 14, 1900
Davis, F. A. W. Vice-Pres. and Treas. Water Co., Indianapolis, Ind.	June 17, 1887
Davis, J. M. Rutland, Vt.	Sept. 13, 1895
Davis, William E. Supt. Water Works, Sherburne, N. Y.	Dec. 11, 1889

NAME.	Date of Election.
Davison, George S. Sec. and Gen. Manager Monongahela Street Railway Co., 512 Smithfield Street, Pittsburg, Pa.	June 15, 1894
Dean, Arthur W. City Engineer, Nashua, N. H.	March 8, 1899
Dean, Francis W. Mechanical Engineer, 53 State Street, Boston, Mass.	June 11, 1890
Dean, Seth, C. E. Glenwood, Iowa.	Dec. 12, 1888
Dean, William H. Water Analyst, Wilkesbarre, Pa.	Sept. 10, 1898
DeBerard, Wilford W. Spring Garden Testing Station, Philadelphia, Pa.	Sept. 19, 1900
Denman, A. N. Des Moines, Iowa.	June 16, 1886
Doane, A. O. Engineering Dept., Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	Jan. 8, 1896
Doten, Leonard S. Supt. of Construction, Quartermaster Dept. U. S. Army, 170 Summer Street, Boston, Mass.	Jan. 8, 1902
Dotten, William T. Supt. Water Works, Winchester, Mass.	June 21, 1882
Downey, Wm. 49 Wellington Street, Worcester, Mass.	June 14, 1899
Drake, Albert B., C. E. 164 William Street, New Bedford, Mass.	April 21, 1885
Drake, Charles E., C. E. New Bedford, Mass.	Jan. 8, 1890
Drown, Thomas M. President Lehigh University, So. Bethlehem, Pa.	June 13, 1888
Dunbar, E. L. Supt. Water Works, Bay City, Mich.	June 9, 1892
Dwelley, Edwin F. 144 Nahant Street, Lynn, Mass.	Sept. 18, 1901
Dyer, Eben R. Supt. of Distribution, Portland, Me.	June 11, 1890
Eardley, B. A. Supt. Pacific Improvement Co. Water Works, Pacific Grove, Monterey County, Cal.	June 15, 1893
Eddy, Harrison P. Supt. Sewer Department, City Hall, Worcester, Mass.	June 15, 1894
Eglee, Charles H. Hydraulic Engineer, 17 Central Street, Boston, Mass.	June 13, 1889
Eldredge, Edward D. Manager Onset Water Co., 49 Monmouth Street, Brookline, Mass.	Feb. 14, 1900
Ellis, George A. Civil Engineer, 158 Sherman Street, Springfield, Mass.	June 21, 1883
Ellis, John W. Civil Engineer, Woonsocket, R. I.	Dec. 11, 1889
Ellsworth, Emory A. Civil and Hydraulic Engineer, Holyoke, Mass.	June 10, 1896

NAME.	Date of Election.
Esterbrook, Arthur F. Water Commissioner, Leicester, Mass.	Sept. 10, 1897
Evans, George E. Civil Engineer, 95 Milk Street, Boston, Mass.	Feb. 14, 1888
Evans, Myron Edward Civil Engineer, 20 Nassau Street, New York City.	June 13, 1900
Ewing, William B. Civil Engineer, La Grange, Ill.	Dec. 13, 1899
Fairbank, J. H. Chairman Water Commissioners, Winchendon, Mass.	March 11, 1896
Falcon, Joseph G. Submarine Engineer, Evanston, Ill.	June 12, 1901
Fales, Frank L. Asst. Engineer, Engineering Dept., Board of Trustees, Commissioners Water Works, Cincinnati, Ohio.	Dec. 13, 1893
Fanning, John T. Consulting Engineer, Kasota Block, Minneapolis, Minn.	April 21, 1885
Farnham, Elmer E. Supt. Water Works, Box 109, Sharon, Mass.	Dec. 11, 1889
Farnum, Loring N. Civil and Hydraulic Engineer, 53 State Street, Boston, Mass.	Dec. 13, 1893
Fels, August Water Commissioner, Lowell, Mass.	Sept. 13, 1899
Felton, B. R. Civil Engineer, Tremont Building, Boston, Mass.	June 9, 1892
Felton, Charles R. City Engineer, City Hall, Brockton, Mass.	Feb. 16, 1894
Fenn, Charles W., C. E. Manager for Mechanics Falls and North Berwick Water Co., 11 Exchange Street, Portland, Me.	Sept. 18, 1901
Ferguson, John N. Asst. Engineer, Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	Dec. 14, 1898
Field, Dr. George W. Biological Dept., Massachusetts Institute of Technology, Boston, Mass.	March 13, 1901
Fisher, Edwin A. City Engineer, 16 Reynolds Street, Rochester, N. Y.	Nov. 13, 1901
Fiske, Henry A. 93 Water Street, Boston, Mass.	Sept. 18, 1901
Fitch, Jasper A. Supt. Water Co., Manchester, Conn.	June 12, 1890
FitzGerald, Desmond Engineer Sudbury Dept., Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	April 21, 1885
Flinn, Richard J., M. E. West Roxbury Station, Boston, Mass.	Sept. 11, 1895
Fobes, A. A. Engineer, Board of Public Works, Pittsfield, Mass.	Feb. 13, 1895
Folwell, A. Prescott Professor of Sanitary and Hydraulic Engineering, Lafayette College, Easton, Pa.	June 15, 1893

NAME.	Date of Election.
Forbes, Fred B. 502 State House, Boston, Mass.	June 14, 1899
Forbes, F. F. Supt. Water Works, Brookline, Mass.	Jan. 29, 1885
Forbes, Murray Manager Westmoreland Water Co., Greensburgh, Pa.	Feb. 11, 1891
Foss, William E. Engineers' Dept., Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	March 8, 1893
Foster, Joel Supt. Water Works, Montpelier, Vt.	Sept. 13, 1895
Foyé, Andrew E., C. E. Acting Chief Engineer, Dept. of Highways and Viaducts, Greater New York, 11 Broadway, New York City.	Dec. 12, 1894
Freeman, John R. President Factory Insurance Co.'s, 812 Banigan Bldg., Providence, R. I.	Dec. 12, 1888
French, D. W. Supt. Hackensack Water Co., Box 98, Weehawken, N. J.	June 9, 1892
French, Edward V. Insurance Inspector, 81 Milk Street, Boston, Mass.	Sept. 10, 1897
French, Frank Baldwin Engineer and Supt. Board of Public Works, Woburn, Mass.	Sept. 16, 1898
Fteley, Alphonse 14 West 131st Street, New York City.	June 18, 1885
Fuller, Andrew D. 3 Hamilton Place, Boston, Mass.	Dec. 15, 1899
Fuller, Frank E. P. O. Box 775, West Newton, Mass.	March 14, 1900
Fuller, Frank L. Civil Engineer, 12 Pearl Street, Boston, Mass.	June 16, 1886
Fuller, George W. 100 William Street, New York City.	March 8, 1893
Gage, Stephen DeM. Biologist Mass. State Board of Health, Lawrence, Mass.	Jan. 10, 1900
Geer, Harvey M. Civil Engineer, Balston Spa, N. Y.	Sept. 10, 1897
Gerhard, William Paul Civil Engineer and Consulting Engineer for Sanitary Works, 33 Union Square, West, New York City.	Dec. 12, 1888
Gerrish, William B. Supt. and Engineer Water Works, Oberlin, Ohio.	Dec. 14, 1892
Gerry, L. L. Civil Engineer, Stoneham, Mass.	Jan. 29, 1885
Gibbs, Harry F. 106 Pond Street, Natick, Mass.	Jan. 11, 1899
Gilbert, Julius C. Water Registrar and Treas. Water Works, Whitman, Mass.	June 15, 1894
Gilderson, D. H. Supt. Water Works, Haverhill, Mass.	Sept. 11, 1895
Gleason, Fred B. Inspector, Marlboro, Mass.	Sept. 13, 1895

NAME.	Date of Election.
Gleason, T. C. Supt. Water Works, Ware, Mass.	June 15, 1894
Glover, Albert S. Tremont Temple Building, Boston, Mass.	June 21, 1882
Goldthwait, W. J. Marblehead, Mass.	June 11, 1890
Goodell, Jerome W. Water Commissioner, Burlington, Vt.	Sept. 18, 1901
Goodell, John Managing Editor "Engineering Record," 100 William Street, New York City.	Sept. 18, 1901
Goodnough, X. H. Engineer State Board of Health, Room 140, State House, Boston, Mass.	Jan. 14, 1891
Gould, Amos A. Water Commissioner, Leicester, Mass.	March 11, 1896
Gould, John A. Chief Engineer, Brookline and Dorchester Gas Light Companies, 1031 Colonial Building, Boylston Street, Boston, Mass.	June 14, 1888
Gow, Frederick W. Supt. Water Works, Medford, Mass.	June 11, 1890
Gowing, E. H., C. E. 12 Pemberton Square, Boston, Mass.	April 21, 1885
Graham, James W. Supt. Meter Dept., Portland Water Co., Portland, Me.	Sept. 13, 1895
Greaney, Thomas F. Water Commissioner, Holyoke, Mass.	March 9, 1898
Greetham, H. W. Local Manager Orlando Water and Sewerage Co., Orlando, Fla.	June 13, 1889
Griffin, J. William Care N. Y. & N. J. Water Co., Arlington, N. J.	Dec. 12, 1900
Groce, William R. Supt. Water Works, Rockland, Mass.	Dec. 12, 1888
Gross, J. F. Inspector Jenkintown Water Co., Jenkintown, Pa.	June 12, 1901
Gubelman, F. J., C. E. 792 Montgomery Street, Jersey City, N. J.	March 11, 1896
Haberstroh, Charles E. Asst. Supt. Metropolitan Water Works, South Framingham, Mass.	Jan. 10, 1900
Hale, Richard A. Principal Assistant Engineer, Essex Co., Lawrence, Mass.	Feb. 14, 1888
Hall, Frank E. 32 Chestnut Street, Quincy, Mass.	June 21, 1882
Hall, Hon. John O. 1230 Hancock Street, Quincy, Mass.	Dec. 12, 1900
Hammatt, E. A. W. Civil Engineer, 53 State Street, Boston, Mass.	June 17, 1887
Hammond, J. C., Jr. Sec'y and Treas., Rockville Water and Aqueduct Co., Rockville, Conn.	Jan. 11, 1888

NAME.	Date of Election.
Hancock, Joseph C. Supt. Water Works, Springfield, Mass.	June 21, 1882
Hapgood, Lyman P. Supt. Athol Water Co., Athol, Mass.	Nov. 14, 1900
Hardy, J. D. Supt. Water Works, Holyoke, Mass.	March 9, 1898
Haring, James S. Civil Engineer, Crafton, Allegheny Co., Pa.	June 9, 1892
Harlow, James H. President Pennsylvania Water Co., Wilkinsburg, Pa. Address Station D, Pittsburg, Pa.	Sept. 10, 1897
Harrington, George W. Wakefield, Mass.	Dec. 10, 1890
Harris, D. A. Supt. Water Works, New Britain, Conn.	March 14, 1888
Hart, Edward W. General Manager Water Works, Council Bluffs, Iowa.	June 10, 1891
Hartwell, David A. City Engineer, Fitchburg, Mass.	Feb. 16, 1894
Hastings, L. M. City Engineer, Cambridge, Mass.	June 13, 1889
Hastings, V. C. Supt. Water Works, Concord, N. H.	June 10, 1886
Hatch, Arthur Elliott Mechanical Engineer, Bay State Dredging Co., 59 High Street, Boston, Mass.	Dec. 11, 1895
Hatch, S. S. Water Commissioner, South Norwalk, Conn.	June 11, 1896
Hathaway, A. R. Water Registrar, Springfield, Mass.	June 10, 1891
Hawes, Louis E. Civil and Hydraulic Engineer, Tremont Building, Boston, Mass.	Dec. 12, 1888
Hawes, William B. Water Commissioner, Fall River, Mass.	June 15, 1894
Hawks, William E. Pres. and Treas. Water Co., Bennington, Vt.	Dec. 12, 1894
Hawley, W. C. Supt. Water Dept., Atlantic City, N. J.	Sept. 8, 1897
Hayes, Ansel G. Asst. Supt. Water Works, Box 323, Middleboro, Mass.	June 13, 1889
Hazard, T. G., Jr. Civil Engineer, Narragansett Pier, R. I.	June 15, 1894
Hazen, Allen Civil Engineer, 220 Broadway, New York City.	June 9, 1892
Heald, Simpson C. Civil Engineer, 48 Congress Street, Boston, Mass.	April 21, 1885
Heermans, Harry C. Supt. Water Works, Corning, N. Y.	June 16, 1886
Hering, Rudolph Hydraulic, Civil, and Sanitary Engineer, 100 William Street, New York City.	June 17, 1887

Name.	Date of Election.
Herschel, Clemens Hydraulic Engineer, 2 Wall Street, Room 68, New York City.	Feb. 10, 1892
Hicks, R. S. 78 Warren Street, New York City.	June 17, 1887
Higgins, James H. Supt. Meter Dept., City Hall, Providence, R. I.	Feb. 8, 1893
Hill, William R. Chief Engineer Croton Aqueduct Commission, 280 Broadway, New York City.	June 9, 1892
Hodgdon, Frank W. Engineer, Mass. Harbor and Land Commission, 131 State House, Boston, Mass.	June 12, 1895
Holden, Horace G. Supt. Pennichuck Water Works, Nashua, N. H.	June 21, 1882
Hollis, Frederick S. Instructor in Chemistry, Yale Medical School, New Haven, Conn.	Dec. 8, 1897
Hook, G. S. Civil Engineer, 705 Union Street, Schenectady, N. Y.	Sept. 13, 1899
Hopkins, Charles C., C. E. Rome, N. Y.	March 10, 1897
Hotchin, George A. Supt. Water Works, Rochester, N. Y.	June 13, 1900
Howard, John L. Division Engineer, Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	Jan. 10, 1900
Hubbard, Winfred D. Supt. Water Works, Concord, Mass.	Sept. 19, 1900
Hubbell, Clarence W. Water Office, Detroit, Mich.	Sept. 13, 1899
Hughes, V. R., M. E. and E. E. 128 Willow Street, Lansing, Mich.	June 12, 1901
Hunking, Arthur W. 374 Stevens Street, Lowell, Mass.	June 11, 1890
Huntington, James A. Water Registrar, Haverhill, Mass.	Dec. 9, 1891
Jackson, Daniel D. Chemist, Division of Water Supply, Mt. Prospect Laboratory, Brooklyn, N. Y.	March 14, 1894
Jackson, William City Engineer, City Hall, Boston, Mass.	June 11, 1890
Johnson, H. R. Water Commissioner, Reading, Mass.	Dec. 14, 1898
Jones, A. J. New Brunswick, N. J.	Dec. 14, 1887
Jones, James A. Water Registrar, Stoneham, Mass.	March 14, 1894
Jordan, John N. Supt. Water Works, Malden, Mass.	June 12, 1896
Judkins, Fred G. Franklin Falls, N. H.	Feb. 14, 1899

NAME.	Date of Election.
Kay, J. William Supt. Water Works, 75 Congress Street, Milford, Mass.	Jan. 9, 1901
Kent, E. W. Supt. Water Works, Woonsocket, R. I.	Feb. 8, 1893
Kent, Willard Manager Water Co., Narragansett Pier, R. I.	April 21, 1885
Kieran, Patrick Supt. Water Works, Fall River, Mass.	June 16, 1886
Kilbourn, Wm. A. Sec'y (Lancaster) Water Commissioners, South Lancaster, Mass.	Dec. 13, 1899
Killam, James W. Metropolitan Water Works, Reading, Mass.	Dec. 13, 1899
Kimball, Frank C. Supt. Knoxville Water Co., 619 South Gay Street, Knoxville, Tenn.	Feb. 12, 1896
Kimball, George A. Chief Engineer Elevated Lines, Boston Elevated Railway, 101 Milk Street, Boston, Mass.	June 17, 1887
Kingman, Horace Supt. Water Works, Brockton, Mass.	June 15, 1893
Kinnicutt, Leonard P. 77 Elm Street, Worcester, Mass.	Feb. 8, 1893
Knapp, Louis H. Engineer Buffalo Water Works, 280 Linwood Avenue, Buffalo, N. Y.	June 17, 1887
Knight, Charles William, C. E. Rome, N. Y.	March 10, 1897
Knowles, Morris Engineer Filtration Dept., Pittsburg, Pa.	June 12, 1895
Knowlton, Charles F. Commissioner of Public Works, Quincy, Mass.	Sept. 19, 1900
Koch, Harry G. Supt. Castle Creek Water Co., Aspen, Col.	Dec. 11, 1889
Kuehn, Jacob L. Supt. Water Co., York, Pa.	June 9, 1892
Kuichling, Emil Consulting Engineer, Rochester, N. Y.	Sept. 10, 1897
Laforest, J. O. Alfred Chief Engineer Laurentian Water and Power Co., La Presse Building, Montreal, Quebec.	Dec. 14, 1892
Lansing, Edward T. E. Civil Engineer, Little Falls, N. Y.	June 13, 1889
Larned, Edward S. Division Engineer Metropolitan Water Works, South Framingham, Mass.	Jan. 10, 1900
Lautz, Adolphe W. Sec'y Water Co., Pekin, Ill.	Sept. 16, 1898
Lawton, Perry Civil Engineer, Savings Bank Building, Quincy, Mass.	Feb. 16, 1894
Lea, R. S. Asst. Professor of Civil Engineering, McGill University, Montreal, P. Q.	June 15, 1893

NAME.	Date of Election.
Learned, Wilbur F. Civil Engineer, Watertown, Mass.	April 21, 1885
Livermore, N. B. 320 Sansom Street, San Francisco, Cal.	Feb. 14, 1900
Locke, James W. Foreman, Brockton, Mass.	Jan. 9, 1895
Lord, Charles S. Sec'y and Manager Winooski Aqueduct Co., Winooski, Vt.	June 12, 1901
Lord, Harry A. Supt. Water Works, Ogdensburg, N. Y.	Sept. 8, 1897
Loretz, Arthur J. L. Mechanical Engineer, 150 Nassau Street, New York City.	Dec. 9, 1896
Lovell, Thomas C. Supt. Water Works, 104 River Street, Fitchburg, Mass.	June 21, 1882
Loweth, Charles F. 1100 Old Colony Building, Chicago, Ill.	Jan. 9, 1901
Luce, Francis H. Supt. Woodhaven Water Supply Co., Woodhaven, N. Y.	June 12, 1896
Ludlow, J. L. 434 Summit Street, Winston, N. C.	Feb. 14, 1900
Lunt, Cyrus M. Supt. Water Works, Lewiston, Me.	Dec. 9, 1896
Lusk, James L. Major, Corps of Engineers, U. S. A., Washington, D. C.	March 13, 1889
Luther, William J., C. E. Asst. Supt. Attleboro Gas Light Co., Attleboro, Mass.	June 15, 1893
McCarthy, Daniel B. Supt. Water Works Co., Waterford, N. Y.	Sept. 11, 1895
McClintock, W. E. Member of Massachusetts Highway Commission, 15 Court Square, Boston, Mass.	June 17, 1887
McClure, Frederick A. City Engineer, Worcester, Mass.	June 15, 1894
McConnell, B. D. Civil Engineer, 185 St. James Street, Montreal, P. Q.	June 12, 1890
McInnes, Frank A. Asst. Engineer Boston Water Works, 23 Salcombe Street, Dorchester, Mass.	Sept. 18, 1901
McIntosh, H. M. City Engineer, Burlington, Vt.	Sept. 11, 1895
McKenzie, Theodore H. Manager Water Works, Southington, Conn.	June 12, 1890
McKenzie, Thomas Supt. Water Works, Box 712, Westerly, R. I.	Dec. 12, 1894
MacLean, Thomas A. Charlottetown, P. E. I., Canada.	Jan. 8, 1902
McMillen, Norman A. Supt. Water Works, North Billerica, Mass.	June 13, 1900
MacMurray, J. C. 33 Oak Ave., Worcester, Mass.	Dec. 9, 1896

NAME.	Date of Election
Mann, Thomas W. Civil Engineer, Holyoke, Mass.	June 9, 1892
Manning, George E. Civil Engineer, New London, Conn.	March 9, 1898
Marble, Arthur D. City Engineer, Lawrence, Mass.	Feb. 12, 1896
Marion, J. A. Civil Engineer, New York Life Building, Montreal, P. Q.	Dec. 13, 1893
Martin, A. E. Supt. Water Company, South Framingham, Mass.	April 21, 1885
Martin, Cyrus B. Treas. Water Co., Norwich, N. Y.	June 17, 1887
Marvell, Edward I. Civil Engineer, 81 Bedford Street, Fall River, Mass.	Jan. 13, 1897
Mason, William P. Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.	Dec. 11, 1895
Mather, Nelson E. Supt. Water Works, Clinton, Mass.	Sept. 19, 1900
Mattice, Asa M. Chief Engineer Westinghouse Electric and Manufacturing Co., East Pittsburg, Pa.	June 15, 1894
Maybury, William E. Supt. Water Works, Braintree, Mass.	Jan. 9, 1901
Maxcy, Josiah S. Treas. Madison Water Co., Gardiner, Me.	Dec. 14, 1887
Mead, Daniel W. Consulting Engineer, 605 First National Bank Building, Chicago, Ill.	Sept. 19, 1900
Merrill, Frank E. Water Commissioner and Supt. Water Works, Somerville, Mass.	Dec. 9, 1896
Merritt, D. S. Engineer and Supt. Water Works, Tarrytown, N. Y.	Dec. 13, 1893
Metcalf, Leonard Civil Engineer, 14 Beacon Street, Boston, Mass.	Feb. 10, 1897
Metcalfe, Henry President Water Board, Cold Spring, N. Y.	June 10, 1896
Miller, A. M. Lieut.-Col. Corps of Engineers, U. S. A., 2728 Pennsylvania Avenue, Washington, D. C.	Nov. 14, 1900
Miller, Hiram A. Clinton, Mass.	March 13, 1901
Miller, John F. Asst. Sec'y Westinghouse Air Brake Co., East Pittsburg, Pa.	June 10, 1896
Miller, P. Schuyler 108 Park Place, Brooklyn, N. Y.	Jan. 10, 1900
Mills, Frank H. City Engineer, Woonsocket, R. I.	Jan. 14, 1891
Mirick, George Langdon Civil Engineer, 104 Porter Street, Malden, Mass.	June 15, 1893

NAME.	Date of Election.
Mixer, Charles A.	Sept. 18, 1901
Resident Engineer, Rumford Falls Light and Water Co., Rumford Falls, Me.	
Moat, C. P.	March 13, 1901
Burlington, Vt.	
Molis, William	June 17, 1887
Supt. Water Works Co., Muscatine, Iowa.	
Moran, John W.	March 13, 1901
Supt. Water Works, Gloucester, Mass.	
Mullhall, John F. J.	Nov. 14, 1900
Treas. Portland (Conn.) Water Co., 11 Beacon Street, Boston, Mass.	
Murdoch, William	Jan. 10, 1900
Supt. Water Works, St. John, N. B.	
Myers, J. H., Jr.	Sept. 11, 1895
Asst. Engineer N. Y. Rapid Transit R. R. Commission, 1261 Clover Street, Bronx, New York City.	
Nash, George D.	March 13, 1901
Supt. Winooski Aqueduct Co., Winooski, Vt.	
Nash, H. A., Jr.	March 13, 1895
Civil Engineer, Weymouth Heights, Mass.	
Naylor, Thomas	Feb. 16, 1894
Maynard, Mass.	
Nettleton, Charles H.	June 16, 1886
Treas. and Supt. Water Co., Birmingham, Conn.	
Newhall, John B.	Dec. 14, 1892
184 Bay Street, Stapleton, Staten Island, N. Y.	
Nichols, Thomas P.	Jan. 10, 1894
Member Water Board, 11 Prospect Street, Lynn, Mass.	
Northrop, Frank L.	June 15, 1893
P. O. Box 1566, Saco, Me.	
Nuebling, Emil L.	Feb. 12, 1896
Engineer and Supt. Water Dept., Reading, Pa.	
Nye, George H.	March 11, 1891
Civil Engineer, New Bedford, Mass.	
Nye, Joseph K.	March 8, 1893
President Water Company, Fairhaven, Mass.	
O'Connell, P. D.	Sept. 16, 1898
Supt. Water Works, Somersworth, N. H.	
Paine, C. W.	Dec. 12, 1888
Constructing Engineer on Extension of Butte City Water Works, Lewisohn Building, Butte, Mont.	
Parker, Charles B.	Jan. 9, 1901
Asst. Supt. Water Works, Cambridge, Mass.	
Parker, Horatio N.	March 10, 1897
456 Bloomfield Avenue, Montclair, N. J.	
Parks, Charles F.	Dec. 11, 1889
Civil Engineer, 11 Beacon Street, Boston, Mass.	
Patch, Walter Woodbury	June 12, 1895
Civil Engineer, Eastern Avenue, South Framingham, Mass.	
Paulison, Washington	Sept. 16, 1898
Supt. Acquackanonk Water Co., Passaic, N. J.	

NAME.	Date of Election.
Payson, E. R. Sec'y Portland Water Co., Portland, Me.	June 13, 1900
Pease, A. G. Water Commissioner, Spencer, Mass.	June 16, 1886
Peene, Edward L. Supt. Water Works, Yonkers, N. Y.	Sept. 16, 1898
Peirce, Charles E. Supt. East Providence Water Co., East Providence Centre, R. I.	Sept. 14, 1887
Perkins, John H. Supt. Watertown and Belmont Water Works, Watertown, Mass.	June 16, 1886
Phillips, Edward Civil Engineer, 11 Broadway, New York City.	Dec. 8, 1897
Pierce, Frank L. 464 Elm Street, Richmond Hill, Queens County, N. Y.	Dec. 14, 1898
Pitcher, Frank H. Chief Engineer Montreal Water and Power Co., 62 Imperial Building, St. James Street, Montreal, P. Q.	June 12, 1901
Pitman, Winthrop M. Treas. North Conway Water and Improvement Co. Address, 493 Centre Street, Jamaica Plain, Mass.	June 17, 1887
Pitney, Frederic V. Engineer Morristown Aqueduct Co., Morristown, N. J.	Feb. 16, 1894
Pollard, William D. General Manager Water Co., Pottsville, Pa.	June 10, 1891
Pope, Macy S. 31 Milk Street, Boston, Mass.	March 13, 1901
Porter, Dwight Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Boston, Mass.	March 13, 1889
Potter, Alexander Civil and Sanitary Engineer, 137 Broadway, New York City.	March 14, 1894
Probst, C. O. Secretary State Board of Health, Columbus, Ohio.	Dec. 8, 1897
Putnam, J. B. Supt. Westboro Water and Sewer Depts., Westboro, Mass.	Sept. 10, 1897
Reynolds, E. H. Brockton, Mass.	June 9, 1892
Rice, George S. Deputy Chief Engineer, Rapid Transit Railroad Commissioners, 320 Broadway, New York City.	Dec. 14, 1892
Rice, James L. Supt. Water Co., Claremont, N. H.	June 15, 1894
Rice, L. Frederick Architect and Civil Engineer, 125 Milk Street, Boston, Mass.	June 17, 1887
Richards, Walter H. Supt. Water Works, New London, Conn.	Oct. 11, 1882
Richardson, T. F. Dept. Engineer Metropolitan Water Works, Clinton, Mass.	Feb. 10, 1897
Ridpath, J. W. Secretary and Manager Water Co., Jenkintown, Pa.	June 9, 1892

NAME.	Date of Election.
Riley, Charles E. Member Water Board, Brookline, Mass.	Sept. 13, 1899
Robbins, F. H. Civil Engineer, 1 Ashburton Place, Boston, Mass.	Sept. 10, 1897
Robertson, George H. Supt. Water Works, Yarmouth, N. S.	June 9, 1892
Robertson, W. W. Water Registrar, Fall River, Mass.	June 17, 1887
Robinson, A. Supt. Water Works, Benicia, Cal.	June 11, 1896
Roden, Thomas Supt. Water Works, Arlington, Mass.	June 12, 1896
Rogers, Thomas H. Pumping Engineer, Pennichuck Water Works, Nashua, N. H.	Sept. 8, 1897
Rotch, William Civil Engineer, Room 742, Exchange Building, 53 State Street, Boston, Mass.	June 16, 1886
Roullier, G. A. Supt. Water Works, Flushing, N. Y.	June 13, 1889
Royce, Harley E. Asst. Engineer, Brookline, Mass.	Jan. 9, 1895
Russell, A. N. President Water Commissioners, Ilion, N. Y.	Sept. 13, 1899
Sando, W. J. Manager Water Works Dept., International Steam Pump Co., Brooklyn, N. Y.	June 12, 1895
Saville, Caleb M. Engineering Dept., Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	March 8, 1893
Scott, Walter M. Resident Engineer Chatham Water Works and Sewerage System, Chatham, N. B.	Nov. 13, 1901
Sears, Walter H. 220 Sandwich Street, Plymouth, Mass.	Sept. 13, 1899
Sealy, W. F. P. Supt. Water Works, Potsdam, N. Y.	Sept. 13, 1895
Sedgwick, William T. Professor of Biology, Massachusetts Institute of Technology, Boston, Mass.	Feb. 12, 1890
Sharples, Philip P. 22 Concord Avenue, Cambridge, Mass.	June 14, 1899
Shedd, Edward M. Inspector Water Works, Somerville, Mass.	Jan. 9, 1901
Shedd, Edward W. Civil Engineer, 146 Westminster Street, Providence, R. I.	March 9, 1892
Shedd, J. Herbert Consulting Engineer, Providence, R. I.	June 13, 1888
Sherman, Charles W. Civil Engineer, Assistant Engineer Metropolitan Water Works, 1 Ashburton Place, Boston, Mass.	Sept. 10, 1897
Sherman, William B. Mechanical Engineer, Box 974, Providence, R. I.	Oct. 11, 1882

Name.	Date of Election.
Sherrerd, Morris R. Engineer Water Dept., Newark, N. J.	March 10, 1897
Shippee, John D. Holliston, Mass.	Jan. 14, 1891
Shirreffs, Reuben Chief Engineer Virginia Electric Railway and Development Co., Richmond, Va.	March 12, 1890
Sinclair, Melville A. Supt. Water Works, Bangor, Me.	June 15, 1894
Smith, Herbert E. Professor of Chemistry, Yale Medical School; Chemist Connecticut State Board of Health. Address, 430 George Street, New Haven, Conn.	Dec. 14, 1892
Smith, H. O. Water Commissioner, Leicester, Mass.	June 15, 1894
Smith, John E. Supt. Water Works, Andover, Mass.	June 10, 1896
Smith, J. J. City Engineer, Grand Forks, N. D.	Nov. 14, 1900
Smith, J. Waldo Supt. Passaic Water Co., 109 Washington Street, Paterson, N. J.	Dec. 13, 1893
Smith, Sidney Civil Engineer, 91 Maple Street, West Roxbury, Mass.	June 12, 1895
Smith, Solon F. Supt. and Treas. Water Co., Grafton, Mass.	June 17, 1887
Snell, George H. Water Commissioner and Supt. Water Works, Attleboro, Mass.	Dec. 12, 1900
Soper, George A. 29 Broadway, New York City.	Jan. 12, 1898
Souther, Henry Water Commissioner, Hartford, Conn.	June 13, 1900
Sparks, H. T. Supt. Water Dept., Public Works Co., Bangor, Me. Address, Box 208, Brewer, Me.	June 15, 1894
Spooner, Herman W. Engineer Gloucester Water Works, 28 Granite Street, Gloucester, Mass.	Nov. 13, 1901
Sprenkel, John F. General Manager York Water Co., York, Pa.	June 12, 1901
Springfield, John F. Civil Engineer, 64 Summer Street, Rochester, N. H.	Jan. 13, 1892
Stacy, George A. Supt. Water Works, Marlboro, Mass.	April 21, 1885
Stearns, Frederic P. Chief Engineer Metropolitan Water and Sewerage Board, 1 Ashburton Place, Boston, Mass.	June 17, 1887
Stevens, James T. Chairman Board of Water Commissioners, South Braintree, Mass.	Jan. 8, 1902
Stevenson, Harry W. Nadine, Allegheny Co., Pa.	Sept. 21, 1900

NAME.	Date of Election.
St. Louis, J. A. Water Registrar, Marlboro, Mass.	Sept. 10, 1897
Stone, Dr. B. H. Burlington, Vt.	March 13, 1901
Stone, Charles A. Electrical Engineer, 93 Federal Street, Boston, Mass.	June 15, 1894
Street, L. Lee 27 Pearl Street, Dorchester, Mass.	Jan. 10, 1900
Sullivan, John C. Holyoke, Mass.	June 15, 1893
Sullivan, J. J. Water Commissioner, Holyoke, Mass.	March 9, 1898
Sullivan, William F. City Engineer's office, Lowell, Mass.	Feb. 14, 1900
Swain, George F. Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.	June 17, 1887
Swan, Joseph W. Asst. Clerk, Water Commissioner's office, Boston, Mass.	Feb. 11, 1891
Taber, Robert W. Water Commissioner, New Bedford, Mass.	Sept. 16, 1898
Taylor, Charles N. Contracting Engineer, Wellesley, Mass.	Feb. 13, 1901
Taylor, Edwin A. Constructing Engineer, 73 Tremont Street, Boston, Mass.	Dec. 14, 1892
Taylor, Frederick L. Engineer, Brookline Water Works, Brookline, Mass.	Feb. 13, 1895
Taylor, Lucian A. Civil Engineer and Contractor, 73 Tremont Street, Boston, Mass.	June 19, 1884
Tenney, D. W. Methuen, Mass.	June 10, 1896
Tenney, Joseph G. Treas. and Supt. Water Works, Leominster, Mass.	June 21, 1882
Thomas, Robert J. Supt. Water Works, Lowell, Mass.	June 9, 1892
Thomas, Harry L. Asst. Supt. Water Co., Hingham, Mass.	Dec. 14, 1898
Thomas, William H. Supt. Water Co., Hingham, Mass.	Dec. 14, 1887
Thomson, John Hydraulic Engineer, 253 Broadway, New York City.	June 9, 1892
Tighe, James L. Engineer Water Works, Holyoke, Mass.	March 9, 1898
Tingley, R. H. Civil Engineer, 75 Westminster Street, Providence, R. I.	Feb. 8, 1893
Tinkham, S. Everett Asst. Engineer, Engineering Dept., City Hall, Boston, Mass.	Jan. 14, 1891
Tompkins, Charles H. Civil Engineer, 120 Liberty Street, New York City.	Dec. 11, 1889

NAME.	Date of Election.
Tower, D. N.	June 17, 1887
Supt. Water Co., Cohasset, Mass.	
Travis, George W.	Dec. 13, 1899
Supt. Water Works, Natick, Mass.	
Treman, E. M.	June 11, 1890
Supt. and Sec'y, Water Co., Ithaca, N. Y.	
Tribus, Louis L.	March 11, 1896
Consulting Civil and Hydraulic Engineer, 84 Warren Street, New York City.	
Tubbs, J. Nelson	June 11, 1890
General Inspector, Dept. of Public Works, State of New York, 207 Wilder Building, Rochester, N. Y.	
Turner, H. N.	Dec. 11, 1895
Manager Water Co., St. Johnsbury, Vt.	
Tuttle, Arthur S.	March 14, 1894
Civil Engineer, Department Water Supply, 82d Street, near 11th Avenue, Brooklyn, N. Y.	
Vallaincourt, J. A.	Sept. 13, 1899
Asst. Treas. Water Co., Berlin, N. H.	
Vaughn, W. H.	Dec. 11, 1889
Supt. Water Works, Wellesley Hills, Mass.	
Venner, John	Jan. 11, 1899
Chief Inspector Bureau of Water, Syracuse, N. Y.	
Wade, William W.	Dec. 8, 1897
Water Registrar, Woburn, Mass.	
Walker, Charles K.	June 21, 1882
Supt. Water Works, Manchester, N. H.	
Walker, John	Dec. 12, 1894
Civil Engineer, Newmarket, N. H.	
Wallace, E. L.	Dec. 14, 1892
Supt. Water Works, Franklin Falls, N. H.	
Warde, Charles S.	Sept. 18, 1901
Cashier Staten Island Water Supply Co., West New Brighton, Staten Island, N. Y.	
Warde, John S.	June 15, 1894
Supt. Staten Island Water Supply Co., West New Brighton, Staten Island, N. Y.	
Warren, H. A.	Dec. 14, 1892
Supt. Water Works, St. Albans, Vt.	
Webster, F. P.	Jan. 8, 1890
Supt. Water Works Co., Lakeport, N. H.	
Wegmann, E.	June 12, 1901
Division Engineer on construction of new Croton Reservoirs, Katonah, N. Y.	
Wescott, George P.	June 16, 1886
Treas. Portland Water Co., Portland, Me.	
West, George F.	Nov. 13, 1901
Manager Water Works, Union Mutual Building, Portland, Me.	
Weston, Robert S.	Sept. 8, 1897
Chemist and Bacteriologist, 14 Beacon Street, Boston, Mass.	
Wheeler, Elbert	Dec. 9, 1891
Treas. Water Co., 14 Beacon Street, Boston, Mass.	

Name.	Date of Election.
Wheeler, William Civil Engineer, 14 Beacon Street, Boston, Mass.	Dec. 11, 1889
Whipple, George C. Mt. Prospect Laboratory, Flatbush Avenue and Eastern Parkway, Brooklyn, N. Y.	Feb. 8, 1893
Whitcomb, W. H. President Water Co., Norway, Me.	June 16, 1886
Whitham, Jay M. Mechanical Engineer, 607 Bullitt Building, Philadelphia, Pa.	Dec. 13, 1893
Whitman, Herbert T. Civil Engineer, 85 Devonshire Street, Boston, Mass.	Feb. 8, 1893
Whitney, John C. Water Commissioner, Newton, Mass.	June 17, 1887
Whittemore, W. P. Supt. Electric Light and Water Depts., North Attleboro, Mass.	June 16, 1886
Wigal, James P. Henderson, Ky.	June 16, 1886
Wilde, George E. Asst. Supt. Metropolitan Water Works, Medford, Mass.	June 16, 1886
Wilder, Frederick W. Treas. Aqueduct Co., Woodstock, Vt.	Dec. 12, 1888
Wilkins, Frank B. Supt. Water Works, Milford, N. H.	Feb. 14, 1900
Williams, Gardner S. Engineer in charge of Hydraulic Laboratory, and Professor of Experimental Hydraulics, Cornell University, Ithaca, N. Y.	June 12, 1895
Williams, William F. City Engineer, New Bedford, Mass.	Feb. 16, 1894
Winslow, C.-E. A. Massachusetts Institute of Technology, Boston, Mass.	Sept. 21, 1900
Winslow, Frederic I. Asst. Engineer, City Engineer's office, City Hall, Boston, Mass.	Jan. 13, 1892
Winslow, George E. Waltham, Mass.	June 18, 1885
Winslow, S. J. Supt. Water Co., Pittsfield, N. H.	June 17, 1887
Wiswall, E. T. West Newton, Mass.	June 13, 1889
Wood, Henry B. Harbor and Land Commission, State House, Boston, Mass.	Dec. 13, 1893
Woodruff, Timothy Supt. Water Works, Bridgeton, N. J.	June 13, 1888
Woods, Henry D. West Newton, Mass.	Jan. 9, 1895
Woods, L. R. Supt. Water Dept., 206 Vine Street, Everett, Mass.	Sept. 18, 1901
Worthington, E., Jr. Civil Engineer, Dedham, Mass.	Jan. 11, 1893
Wright, George W. Chief Engineer, Water Dept., Box 426, Norfolk, Va.	June 9, 1892

Name.	Date of Election.
Yorston, W. G.	Dec. 14, 1892
Constructing Engineer, Box 470, Truro, N. S.	
Youngren, Carl J.	Dec. 13, 1899
Boston Water Dept., City Hall, Boston, Mass.	
Zick, W. G.	June 15, 1893
253 Broadway, New York City.	

Honorary Members.

Frost, George H.	June 16, 1886
President Engineering News Pub. Co., St. Paul Building, New York City.	
Gale, James M.	Jan. 16, 1889
Engineer-in-Chief Loch Katrine Water Works, Glasgow, Scotland.	
Meyer, Henry C.	June 17, 1887
The Engineering Record, 100 William Street, New York City.	
Shepperd, F. W.	Feb. 12, 1890
"Fire and Water," Bennett Building, Nassau and Fulton streets, New York City.	

Associates.

Allis-Chalmers Co.	Dec. 13, 1893
"High Duty Pumping Engines," Milwaukee, Wis.	
Ashton Valve Co.	June 18, 1885
"Water Relief Valves," 271 Franklin Street, Boston, Mass.	
Barr Pumping Engine Co.	Feb. 13, 1901
Philadelphia, Pa.	
Harold L. Bond & Co.	Dec. 12, 1900
"Construction Work Supplies," 140 Pearl Street, Boston, Mass.	
Brandt, Randolph	April 21, 1885
"Selden Patent Packing," 38 Cortlandt Street, New York City.	
Brewster, H. M. (E. Stebbens Mfg. Co.)	June 13, 1888
"Brass Goods," Brightwood P. O., Springfield, Mass.	
Builders Iron Foundry	June 17, 1887
P. O. Box 218, Providence, R. I.	
J. B. Campbell Brass Works	Sept. 18, 1901
16th and Cascade streets, Erie, Pa.	
Chadwick-Boston Lead Co.	April 21, 1885
162 Congress and 180-182 Franklin streets, Boston, Mass.	
Chapman Valve Mfg. Co.	June 21, 1883
"Valves and Hydrants," Indian Orchard, Mass.	
Charles A. Claflin & Co.	Jan. 9, 1901
"Steam Engineering and Water Works Supplies," 188 Franklin Street, Boston, Mass.	
Coffin Valve Co.	June 16, 1886
"Valves and Hydrants," Neponset, Boston, Mass.	
Deane Steam Pump Co.	April 21, 1885
"Steam Pumps and Pumping Machinery," Holyoke, Mass.	
Dibble, F. J.	June 11, 1890
"Electric Gages," Peabody, Mass.	

NAME.	Date of Election.
Drummond, M. J. "Cast Iron Pipe," 192 Broadway, Corbin Building, New York City.	Dec. 14, 1887
Dunne, George C. Manager Portland Stoneware Co., 42 Oliver Street, Boston, Mass.	Feb. 10, 1892
Eagle Oil and Supply Co. 104 Broad Street, Boston, Mass.	June 15, 1894
Garlock Packing Co. "Packing," 12 Pearl Street, Boston, Mass.	June 11, 1896
William H. Gallison Co. "Engineer's Supplies, Pipe, etc.," 36 Oliver Street, Boston, Mass.	June 18, 1885
Gilchrist, George E. "Pipes and Fittings," 106 High Street, corner Congress Street, Boston, Mass.	Jan. 11, 1888
The Goulds Mfg. Co. "Engines," 236 Congress Street, Boston, Mass.	Sept. 11, 1895
Hersey Mfg. Co. "Meters," South Boston, Mass.	June 16, 1886
International Steam Pump Co. P. O. Box 14, Brooklyn, N. Y.	June 12, 1901
Jenks, Henry F. "Drinking Fountains," Pawtucket, R. I.	April 21, 1885
Kennedy Valve Co. "Valves, Hydrants, and Indicating Devices," 57 Beekman and 87 Ann streets, New York City.	Sept. 8, 1897
Lamb & Ritchie "Tin-lined Iron Pipe and Lead-lined Iron Pipe," Cambridge, Mass.	Dec. 12, 1900
Lead Lined Iron Pipe Co. "Lead and Tin Lined Pipe," Wakefield, Mass.	Sept. 8, 1897
Libbey, Parker & Co. "Plumbing, Steam, Water Works Specialties and Supplies," 416 Atlantic Avenue, Boston, Mass.	March 14, 1900
Ludlow Valve Mfg. Co. "Valves and Hydrants," 150 High Street, Boston, Mass.	June 18, 1885
Lynch, John E. Proprietor "E. Hodge & Co., Stand Pipes," East Boston, Mass.	June 10, 1891
Montreal Pipe Foundry Co., Lt'd Acadia Mines, Londonderry, N. S.	Jan. 8, 1902
Moore, Charles A. "Engines, Boilers, and Supplies," 85 Liberty Street, New York City.	Dec. 9, 1896
I. P. Morris Co. "Pumping Engines and Turbines," corner Beach and Ball streets, Philadelphia, Pa.	June 15, 1894
H. Mueller Mfg. Co. "Water Works Supplies," Decatur, Ill.	Sept. 11, 1895
National Lead Co. (Boston Branch) 89 State Street, Boston, Mass.	March 14, 1894

NAME.	Date of Election.
National Meter Co. "Meters," 84 Chambers Street, New York City.	Oct. 11, 1882
National Tube Co. "Pipe and Fittings," McKeesport, Pa. Address, 95 Milk Street, Boston, Mass.	April 21, 1885
Neptune Meter Co. "Trident Water Meters," Jackson Avenue and Crane Street, Long Island City, N. Y.	June 15, 1893
New York Continental Jewell Filtration Co. "Filters," 15 Broad Street, New York City.	June 15, 1894
Norwood Engineering Co. "Hydrants, Filters, etc." Florence, Mass.	April 21, 1885
Peck Bros. & Co. "Water Works Supplies," 65 Oliver Street, Boston, Mass.	Dec. 12, 1894
Perrin, Seamans & Co. "Construction Tools and Supplies," 57 Oliver Street, Boston, Mass.	June 11, 1890
Pittsburg Meter Co. "Water Meters," East Pittsburg, Pa.	June 15, 1894
Rensselaer Mfg. Co. "Valves and Water Gates, and Sole Manufacturers of Corey Fire Hydrant," Troy, N. Y.	June 11, 1890
Roberts, C. E. Hartford Steam Boiler Inspection and Insurance Co., 125 Milk Street, Telephone Building, Boston, Mass.	March 13, 1889
Robinson, Edward "Wells Light Mfg. Co.," 44-46 Washington Street, New York City.	Dec. 13, 1899
Ross Valve Co. "Valves," Troy, N. Y.	June 13, 1888
Sampson, George H. "Powder," 13 Pearl Street, Boston, Mass.	June 18, 1885
A. P. Smith Mfg. Co. "Tapping Machines," Passaic Avenue, foot of Brill Street, Newark, N. J.	Feb. 10, 1892
B. F. Smith & Bro. "Artesian and Driven Wells," 38 Oliver Street, Boston, Mass.	Sept. 10, 1897
Sumner & Goodwin Co. "Water Works Supplies," 287 Congress Street, Boston, Mass.	April 21, 1885
Sweet & Doyle Selling Agents Vincent Valves, Cohoes, N. Y.	June 13, 1900
Thomson Meter Co. "Water Meters," 79 Washington Street, Brooklyn, N. Y.	June 13, 1888
Union Water Meter Co. "Water Meters," 31 Hermon Street, Worcester, Mass.	June 21, 1883
United States Cast Iron Pipe and Foundry Co. Corner Broad and Chestnut streets, Philadelphia, Pa.	Sept. 13, 1899
Waldo Bros. "Contractors' Supplies," 102 Milk Street, Boston, Mass.	April 21, 1885
Walworth Mfg. Co. "Pipe, Brass Work, Service Boxes, etc.," 134 Federal Street, Boston, Mass.	April 21, 1885

NAME.	Date of Election.
R. D. Wood & Co. "Cast Iron Pipe," 400 Chestnut Street, Philadelphia, Pa.	June 19, 1884
The George Woodman Co. "Pipe and Fittings," 41 Pearl Street, Boston, Mass. P. O. Box 3653.	April 21, 1885

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ARGENTINA. *Buenos Aires* — Charles Anthony, Jr.

THE DRAINAGE OF SWAMPS FOR WATERSHED IMPROVEMENT.

BY EDWARD S. LARNED, DIVISION ENGINEER, METROPOLITAN WATER WORKS, SOUTH FRAMINGHAM, MASS.

[*Presented December 11, 1901.*]

In the development of the water supply of Boston and the Metropolitan District, the aim has been to provide not only an abundant supply, but a quality of water wholesome and attractive in appearance and taste. Great care and much expense have been devoted to the preparation of storage reservoir sites, in the removal of soil and organic matter, providing against shallow flowage, and keeping the watersheds free from contamination by sewage or other waste products of human life and industry.

The quality and appearance of all surface waters, such as ponds, lakes, rivers, and brooks, are affected by the physical characteristics of the areas drained, and when a watershed contains many swamps, it is known that the effluent streams will contain a large amount of dissolved organic matter, giving the water a deep color and furnishing food products for organisms that under certain conditions will impart a most unpleasant odor and taste to the water in the storage reservoirs.

While it is generally supposed that water unpleasant to the sight, taste, and smell from such causes is innocuous, we have it on good medical authority that it superinduces bowel complaints, zymotic troubles, dysentery, and low fevers.

In the case of an unpolluted dark surface water, the color is generally indicative of the amount and condition of the organic matter present, and any improvement tending to reduce the color will prove of value not alone from the æsthetic view, improving the appearance of the water, but, by a corresponding reduction in the supply of nitrogenous food for animal and vegetable organisms, tends to remove one of the most important factors in producing bad tastes and odors in the water of storage reservoirs.

In a large reservoir suitably prepared by the removal of all soil and vegetable matter, a marked reduction of color will be noted in

water not changed oftener than once in eight months, and if allowed to remain in storage for a year or more, it will become practically colorless. This fact is established under the investigations of the Massachusetts State Board of Health, and a very instructive discussion of the subject is found in the special report of this board, on Examinations of Water Supplies, for the year 1890, by Dr. Thomas M. Drown, chemist of the board.

Ideal conditions of storage and watershed are seldom attainable, and it follows that the purer a water can be delivered to the storage reservoir, assuming the latter to be properly cleaned out, the less the chance of deterioration and the more wholesome and acceptable it will be to the consumer.

SWAMP DRAINS.

In the Sudbury watershed the many swamps existing along the brooks tributary to Framingham Reservoir No. 3, the new Sudbury Reservoir, and the open channel at the lower end of the Wachusett Aqueduct, which flows into the Sudbury Reservoir, made it seem expedient to construct a system of ditches to intercept or facilitate the passage of water from the uplands through or around the swamps. The latter are generally very nearly level, without well-defined water courses, and such as are found are badly congested with rank vegetation and rotting wood; soundings find the mud or peat deposit from one foot to more than thirty feet in depth. Most of the swamps are timbered, the growth being maple, pine, alder, birch, chestnut, elm, dogwood, and cedar, with often a rank undergrowth, and it is to be expected that water held in check or passing slowly through such a place would acquire a high color. Figs. 1 and 2, Plate I, show conditions characteristic of the swamps.

In order to properly locate and determine the capacity of the ditch required, a survey is made showing the outlines of the swamp; soundings and surface elevations are taken from the edge of the swamp out to a point beyond the probable location of the ditch, with an occasional cross section over the full width of the swamp; influent brooks are noted; the limits of timber and open land located; property lines taken, and a reconnoisance of the limits of the watershed above the point of the proposed improvement is made. A paper or plan location is made, the line run out on the ground and adjusted, if necessary, to escape bowlders or other difficulties not indicated in the preliminary survey.

When the swamp is long and narrow, a single ditch suffices, located on the side from which the larger yield is received; the influent brooks, if any, on the opposite side of the swamp are to be led by cross drains into the main ditch.

In the case of a more extensive swamp, the drains are constructed on the edge surrounding it, thus intercepting the entire upland yield, and carrying the water by, before it comes in contact with any part of the swamp; and with the bottom of the ditches usually below the peat formation, in sand or gravel, it follows that more or less ground water is also cut off from the swamp, and the latter soon becomes moderately dry and capable of producing a good quality of grass if cultivated; this further improvement is encouraged among the land owners, particularly in the case of abandoned or neglected meadows, and the opportunity thus afforded by adequate drainage to reclaim land has been an important factor in securing ditching rights through private land without payment therefor. In this connection it may be stated that all of the improvement effected under supervision of the writer was through private land; 47 411 feet of improved ditches were constructed, passing through or affecting twenty-seven separate estates, and the necessary rights were secured at a total expenditure for damages, real or fancied, of $49.82.

In negotiating with the land owner, the nature and extent of the proposed improvement were explained in detail; the benefits to be derived by both parties to the agreement pointed out; ample time for consideration was given, and oftentimes several interviews were necessary; it is not uncommon to find men loth to grant any privilege to a municipality or commonwealth without a money consideration, though they suffer no loss or damage and even derive a benefit thereby. Upon securing consent, the following simple form was filled out and signed: —

I, (John Brown,) of Southboro, Mass., hereby consent that the Metropolitan Water Board may, without charge, dig and maintain channels for the drainage of my low land in Southboro, substantially on lines shown on a plan hereto annexed, entitled, "DRAINAGE OF SWAMPS," "ANGELICO BROOK," dated May, 1900.

The earth removed from such new channels shall be neatly leveled off or used in filling the channels of existing brooks wherever I may permit such filling.

(Four) (4) bridges shall be built in a substantial manner across said channels at points to be designated by me.

PLATE I.

FIG. 1. — WOODED SWAMP.

FIG. 2. — OUTLET OF SWAMP IN BOWLDER GROUND.

(Two) (2) watering places shall be provided at points to be designated by me.

Said board shall have the right to cut and remove all wood and timber on land owned by me within twenty feet from the center and on each side of said drain, and agrees as part consideration for this agreement to haul to hard land and cord up all wood cut on said lands under the provisions of this agreement, or shall leave the same in the log if so directed.

In consideration of the benefits to be derived by me from the foregoing arrangement, I agree without further consideration, etc.

(Signed) JOHN BROWN.

MAY 15, 1900.

Some were found willing to promote the improvement in every way; individual effort to drain land was not uncommon, but usually ineffectual through want of combined action on the part of adjacent owners, poor construction and maintenance.

The drain constructed by the Metropolitan Water Works, a cross section of which is shown in Fig. 1, is designed to carry three quarters of an inch of rainfall collected in twenty-four hours, at a velocity not to exceed two feet per second; this capacity is deemed sufficient except at times of extreme high flow, too infrequent to warrant special provision therefor.

SECTION OF DITCH

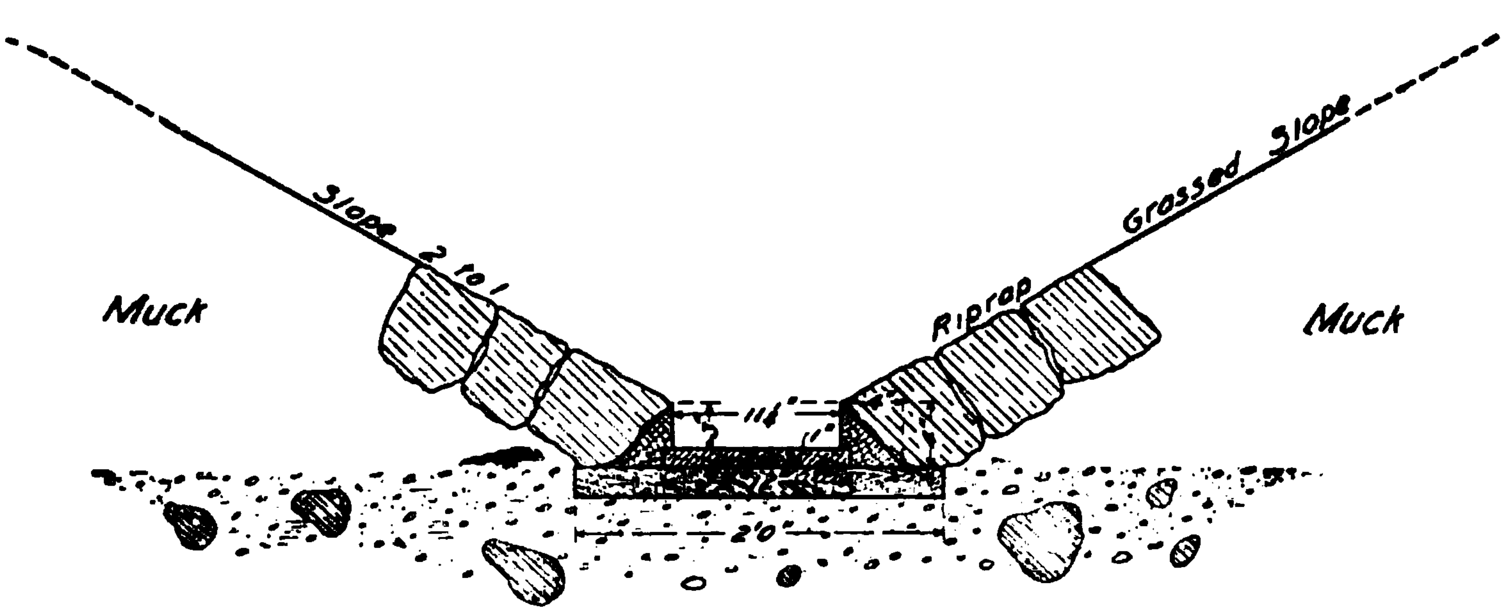

FIG. 1.

The drain has a board bottom, twelve inches wide, upper side planed, resting on mud-sills 2″ x 4″ x 2′, spaced about three feet apart and set flush with the ground; on either side are wood strips made of 4″ x 4″ stock, sawed on the diagonal and rabbeted to set

over the edge of the board about three eighths of an inch, serving as a footing for the stone paving on the sides of the channel, and to hold the boards in place when the nails used may give out through the action of rust.

The side slopes, two horizontal to one vertical, are protected by paving from six to nine inches thick, up to a point above the normal surface of the water; at all turns and connecting ditches the exposed slopes are protected by paving for the full height; paved gutters are made for influent streams coming in from the side. Fig. 1, Plate II, shows the clearing made through woodland, and Fig. 2 shows character of riprap placed, also including platform bridge placed at a farm-road crossing.

It will appear that straight line construction is necessary; but all deflections over thirty degrees are eased off by several short panels. In timber, sprout, or brush land, a clearing forty feet wide is made; this serves to keep falling leaves out of the ditch and during construction offers an opportunity for teams hauling lumber and stone to deliver material close by the work; the tree-tops, small brush, and swamp grass were often used to support the wagons over soft ground, and frequently both stone and lumber had to be carried in to the work from the nearest accessible point on hard land. Lumber was obtained in carload lots, and the haul from nearest railroad station averaged from one to three miles. All stones found in the excavations were used for paving, but were a small part of the amount required; the farmers donated many old walls, pasture lots furnished some by grubbing; and in some instances stones were purchased at ten cents per load and the farmers employed to haul them; this, however, was only done as a means to secure the ditching rights.

The depth of the ditches averages two feet, and varies between one and one-half and three feet. The excavated material was used to fill up all old brook courses and low places near by; any surplus was spread thin on the swamp side of the ditch and gaps left in the filling at frequent intervals and at all low places, to freely admit water into the ditch at times of freshet. For the convenience of the land owner, culverts or bridges over the drain are built at farm-road crossings and other points where necessary; watering places provided for grazing stock by depressing the bottom of the ditch from eight to twelve inches for the length of one board (usually sixteen feet), and taking out one or both sides of the ditch to a flat slope, and pro-

PLATE II.

FIG. 1.—SHOWING CLEARING MADE IN WOODED SWAMP.

FIG. 2.—SHOWING RIPRAP PROTECTION AT CONNECTING DITCHES.

tecting the bottom with paving or gravel; the trough being in line with the ditch provides for free circulation and avoids the tendency to stagnation, which exists if placed on the side.

To explain method of construction: the clearing is made well in advance of excavation, and stumps found within the lines of the ditch are removed; a trench three feet wide, with vertical sides, is dug to within a few inches of grade; line and grade stakes are then driven in the trench every twenty-five feet, one foot off center and with a nail in the side one foot above sill grade; one man undercuts the sides to admit the paving, working to the line; another man or two remove the few inches of material remaining to grade; two men follow with spirit level, mattock, and rammer, setting the sills; two men in turn place the boards to line, nail to sills, and spike on the side strips; then come a gang of pavers, followed by a gang trimming slopes and grading.

The success, from the point of expense, of the work depends upon one operation following the other immediately; pumping is an expensive item, and one operation must be made to serve the board laying, paving, and sloping.

A succession of swamps, large and small, may often be found along the course of a brook, with various stretches of swiftly flowing water between; of course in this case the ditches are not made continuous, but sufficient work is done in the original brook bed to lead the water directly into the drain, and to secure a good run-off at the lower end; in this way, in connection with the 47 411 feet of improved ditch, 2 500 feet of the original brook courses were cleaned out and deepened.

Experience as usual proved a good teacher, and the work of the second season was accomplished at a lower cost than that of the first.

The work of swamp drainage was begun in 1898 by the Dam and Aqueduct Department; to the end of 1900 this department constructed 82 099 feet of ditches in the Sudbury watershed in connection with swamps draining into the open channel of the Wachusett Aqueduct, and 15 048 feet of ditches in the Wachusett watershed. The Sudbury department began work in 1899 and completed the improvement on five brooks tributary to the Sudbury Reservoir and Framingham Reservoir No. 3 during the following year.

The following table shows the cost of all the swamp drains constructed by the Sudbury department, exclusive of engineering: —

Location.	Timbered Ditch (Feet).	Total Cost.	Cost per Foot.
Angelico Brook	9 702	$3 904.83	$0.402
Brewer Brook	5 500	1 343.59	.244
Deerfoot Brook	7 876	2 449.61	.311
Mowry and Broad Meadow Brooks	24 333	5 717.76	.235
Total	47 411	$13 415.79	
Average			$0.283

The work was done by day labor, receiving $1.50 for nine hours' work; a few men were paid from $1.80 to $2.00 per day.

During 1900 a careful cost account was kept for the 24 333 feet of ditches on the Mowry and Broad Meadow Brook Improvement, as follows: —

LABOR COST ONLY.

Period. Sept. 1 to Dec. 8	Excavation and Clearing.	Timber Bottom.	Riprap and Stone Deliv.	Drilling and Blasting.	Culverts and Bridges.
Average cost per foot	0.093	0.024	0.052	0.004	0.006

Total average labor cost per lineal foot of ditch	$0.179
Lumber, hardware, blasting supplies, etc.	.056
Total average cost per foot	$0.235

STATEMENT OF WORK.

Length of drain through woodland, 13 410 feet.
Length of drain through meadowland, 10 923 feet.
9 stone culverts (average 2.8 x 2.6), 109 feet.
21 timber bridges, chestnut stringers, 2″ plank floor, average 8′ x 10′.
10 watering places.
2″ x 4″ spruce, average cost $13.50 per M, 16 535 feet B. M. used.
4″ x 4″ spruce (side rails) average cost $15.93 per M, 32 582 feet B. M. used.
1″ x 12″ spruce and Pennsylvania hemlock, average cost $17.11 per M, 25 171 feet B. M. used.

NOTE. —Lumber cost f. o. b. cars delivered.
Average cost of lumber per foot of ditch, $0.048.

It remains to be shown what improvement in color of water has been observed.

Since the construction of the ditches, color observations have been taken once each month, about the 15th, at a given point near the reservoir into which the brook flows. Prior to the improvement, color determinations had been made from the same points in the same way for a period covering at least one year, and in most instances a longer time.

The following table, prepared under the direction of Mr. Desmond FitzGerald, engineer of the Sudbury department, is intended to show the improvement up to May 15, 1901: —

SUMMARY OF NORMAL COLORS AND REDUCTION OF COLORS BY DITCHING.

	Normal Color before Ditching.	Normal Color after Ditching.	Difference.	Reduction of Color, Per Cent.
Brewer Brook	0.70	0.58	0.12	17
Angelico Brook	1.15	0.79	0.36	31
Deerfoot Brook	1.27	0.90	0.37	29
Choate Brook	1.15	0.60	0.55	48
Outlet of Crane Swamp	1.81	1.08	0.73	40
Brigham's Pond Brook	0.81	0.59	0.22	27
Mowry Brook	0.63	0.48	0.15	24
Broad Meadow Brook	0.59	0.51	0.08	14
Average				29

Normal colors have been computed from observed colors by multiplying each observation by the yield of the Sudbury watershed for the month during which the observation was made, and dividing the sum of the products by the sum of the yields (multipliers).

It is known that local conditions may seriously affect the result of one observation, and it would appear desirable to have the ob servations made oftener than once a month or extended over a longer period before predicating results, but it seems conservative to expect a reduction of color of at least thirty per cent. from swamp drainage, and in aggravated cases it would probably be much greater.

In the above table the differences in the reduction of color are accounted for in the ratio of swamp area to total drainage area, the location of the swamp with reference to the outlet of the brook and the point at which color determinations are made. It is apparent that a greater reduction of color would follow when ninety per cent. of the entire yield passed through a swamp, than in a case where only twenty-five per cent. came in contact with the swamp.

The writer is of the opinion that with the maintenance of these drains and the gradual reclamation of swampy meadows by the land owners, which is reasonably sure to follow, and is even now in progress, the greatest improvement is yet to come.

It may be only a coincidence, but in the case of the Choate Brook, which shows the greatest improvement in color of any of the

brooks treated, a large, swampy meadow contiguous to the drain was immediately reclaimed by the owner and converted into a fine grass-producing meadow. Figs. 1 and 2, Plate III, show characteristic conditions observed before and after drainage.

DISCUSSION.

THE CHAIRMAN. With the exception of those cities and towns which depend entirely on driven well supplies, I suppose there is hardly a place which is not troubled at times with either a discoloration or a bad taste in the water. The subject is open for discussion.

MR. HORATIO N. PARKER.* Mr. Larned has pointed out that the drainage of the swamps is a very effective method of preventing the growth of microscopic organisms. I should like to emphasize this and recommend the speaker's treatment to the members as a means of reducing the evils from this source in their reservoirs. These swamp waters usually contain a large amount of carbonic acid, which recent experiments † have shown to be one of the chief food materials of the microscopic organisms; so when these waters come into a reservoir they not only may bring large growths but they are likely to stimulate the development of forms already living there. The two last pictures are very instructive. The swamp as we saw it in Fig. 1, Plate III, with its half-submerged vegetation and quiet water, was an ideal place for plankton development. A heavy rain will wash the organisms out of the swamp into the storage reservoir, where they are likely to grow and make the water unfit for drinking, on account of the unpleasant taste and odor which they produce. The second picture shows this danger entirely removed. Undoubtedly there are many supplies in the care of the gentlemen here to-day which would be greatly improved by drainage of the surrounding swamps. In addition to this, the drainage of these places would be of great benefit to the comfort and health of the communities in which they are situated, for these swamps are the breeding places of hosts of mosquitoes, which are terrible pests, and which modern science has shown to be the vehicles of malaria and other diseases.

THE CHAIRMAN. I will call upon Mr. Richards; I think he has had some experience in this matter.

* Biologist, Metropolitan Water Works.

† Journal of the American Microscopical Society, 1901.

PLATE III.

FIG. 1.—BEFORE DRAINAGE.

FIG. 2.—AFTER DRAINAGE.

Mr. Walter H. Richards.* Mr. President and gentlemen, I happen to have had only one experience of this kind, and that was about ten years ago, when we drained a swamp of perhaps one hundred acres, by a method very similar to that the gentleman has described, except that we constructed our ditches on either side of the swamp and carried the upland water into our reservoir. The swamp happened to be so situated that we could take the water from the swamp and discharge that into another watershed outside of the watershed of our reservoir. By this means we took the water from the hillsides and carried it into our reservoir, and took the water from the swamp and carried it away from the reservoir. We were very successful in reducing the color. We did not make any exact determinations of the color, but the improvement was very apparent to the naked eye, from an extremely highly colored water to a water which was nearly white.

The Chairman. I will now call upon Mr. Sherman.

Mr. Charles W. Sherman.† Mr. President, I do not know that I can add anything to this discussion except a few words in regard to the figures upon which Mr. Larned has based the statements of the percentage of reduction of color. It fell to my lot to do most of the actual computing of those figures, and it is only fair to say that the reduction in color shown in many cases is the reduction in the color of the brook water near the point at which it is discharged into the reservoir, rather than near the outlet of the swamp. In the cases of the swamps which showed the largest percentage of reduction of color, which were forty and forty-eight, the observations, both before and after the improvement, were made at the outlet of the swamp, which was the same point as the point of discharge into the reservoir; that is, the swamp covered the whole area down to the reservoir, or to the main channel leading to it. In the other cases the swamps which were improved by ditching are situated rather near the limit of the watershed, and at a considerable distance from the reservoir proper, while the color observations were made at points near the reservoir; consequently the color before the improvement was made indicated the combined color of the water from the swamps and of a considerable quantity of upland water contributed to the brook below the swamp, that color, of course, being much less than the color of the water at the outlet of the swamp.

* Superintendent of Water Works, New London, Conn.

† Assistant Engineer, Metropolitan Water Works.

In the same way the color since the improvement was made, being at the same point, represents the color of a mixture of this same upland water and the water from the swamp which has been improved in color, an amount which, owing to lack of observation, is not directly determined. Consequently, where an improvement of perhaps fourteen or seventeen per cent. in color is shown, in all probability it means an actual improvement of from twenty-five to thirty-five per cent. in the color of the water discharged from the swamp in which the ditches were constructed. That point should be borne in mind in considering the apparently small percentage of reduction in color shown in some of the cases.

This condition is well shown in Fig. 2, which shows that part of the Sudbury watershed tributary to the open channel of the Wachusett Aqueduct, Sudbury Reservoir (formerly called No. 5), and Framingham Reservoir No. 3. The location of the ditches built is indicated by the heavy lines in or surrounding the swamps. The numbered points show *all* the points where observations of the color of the brook waters have been made at any time. The normal colors quoted by Mr. Larned were for the following points: —

Brooks tributary to Framingham Reservoir No. 3.

Brewer Brook, point (3).
Angelico Brook, point (5).

Brooks tributary to Sudbury Reservoir.

Deerfoot Brook, point (4).
Mowry Brook, point (15).
Broad Meadow Brook, point (20).

Brooks tributary to open channel of Wachusett Aqueduct.

Brigham's Pond Brook, point (4).
Crane Swamp, point (17).
Choate Brook, point (8).

Observations at other points were too few to warrant the computation of normal colors.

THE CHAIRMAN. Mr. Brooks, I think, has had quite an experience with drainage on the Cambridge works.

MR. EDWIN C. BROOKS.* I will say that although we have quite a large amount of swamp land tributary to our supply in Cambridge, very little has been done so far in the way of drainage. Our large

* Superintendent, Cambridge Water Works.

Fig. 2.

storage reservoir has operated very well to bleach out the water which comes from the Hobbs Brook section, and so the color has been kept down in that branch of the works. We expect, however, to go on with quite a system of ditching, which we think will improve matters very materially.

THE CHAIRMAN. At the time of our meeting in New Bedford, some twelve or fifteen years ago, we noticed that the water there was so highly discolored that it was almost impossible to tell it from other liquids which New Bedford is noted for. Perhaps Mr. Coggeshall can give us some information.

MR. R. C. P. COGGESHALL.* That water came from the old Acushnet Reservoir, which was the original supply and which is not now in use. This basin is surrounded by numerous swamps, which is the reason of this discoloration. Since the introduction of the new supply, in 1899, all our water is taken directly from Little Quittacas Pond.

MR. LARNED. An instance of organic contamination which may be of some interest, and perhaps is known to some of the gentlemen present, I had occasion to look into in connection with the water supply of Butte, Mont., a few years ago. They were constructing a new reservoir there, and, although it was unfinished, the reservoir had been allowed to partially fill, and they were using the water from it. At the head waters of the reservoir was a large swamp. At one season of the year, I think it was in June or July, the water became so foul that it was unsuited to almost all domestic uses. The color was a very dark chocolate. You could not destroy the odor by boiling; it tainted potatoes; it could not be used in making coffee; it was absolutely unfit to bathe in; and it was so noxious to smell that the City Fathers contemplated passing an ordinance forbidding its use for sprinkling the streets.

I have n't heard what was finally done. I believe one of the superintendents of the company was sent East to advise with experts in the matter, and swamp drainage was advised; and, as a preliminary betterment, they advised the construction of a flume leading from the head waters of the swamp around the swamp, which I believe was done. But it took a long time for the water to improve in the reservoir, and the community suffered meanwhile. It was harvest time for the owners of many little springs which are located in the valleys about there, the water being

*Superintendent, New Bedford Water Works.

peddled out, at the rate of from ten to fifteen cents a pail, through the town.

THE CHAIRMAN. We should be glad to hear from any one else who has had any experience in this matter.

MR. LEONARD METCALF.* There are one or two questions I should like to ask Mr. Larned. One is in regard to the grades at which some of these ditches have been laid, how flat the grades are; and the other is in regard to maintenance, whether it is found necessary once or twice a year to go over the ditches with a squilgee, or something of that sort, to clean them out, and how much material is washed in.

MR. LARNED. I stated, I believe, in the text of the paper, that the velocity was kept down to something under two feet per second. The grade which was followed to attain that velocity was generally about one foot in one thousand feet; and in many cases, where we did n't have a fall through the swamp and were required to secure this velocity in the water surface itself, we built deeper ditches, sometimes almost level.

In connection with the maintenance of the ditch, and perhaps the life of the ditch, it may be of interest to state that that will depend somewhat upon the board bottom being kept covered with water. Some of these ditches have been in existence now for about three years, and I believe they are in a fair state of preservation to-day. But it is conceivable with following periods of wet and dry the boards might rot rather rapidly.

The maintenance of the work requires one or two men to go over the ditches perhaps twice a year. In the spring of the year there may be a small amount of débris that has blown in or collected in the ditch, and that is very readily removed by a man taking a square-pointed shovel, — the width of the ditch is about eleven inches and a quarter, just a trifle more than the width of the shovel, — and he simply walks along the smooth bottom, pushing the shovel before him until he collects a shovelful of material, which he throws on the side of the ditch. There were about twenty-three thousand feet of ditches constructed the first season, and the total cost of cleaning them out, making needed repairs to the side slopes and paving due to frost upheaval, etc., amounted to about twenty-five dollars the first season, or about one dollar per one thousand feet.

MR. COGGESHALL. Previous to 1886 the only supply of the city

* Civil Engineer, Boston, Mass.

of New Bedford was from the Acushnet Reservoir. That supply became scant at times, and a drought in the latter part of 1886 necessitated prompt action in procuring an additional supply. Less than two miles north of the head waters of the Acushnet Reservoir is Quittacas Pond, which is now our source of supply. We put men at work and dug a ditch something less than a mile and a half long, and for over a mile the sides are laid with plank and braced. The grade of the bottom of the ditch is not over a foot in its whole length. That served the purpose for which it was intended up to the time the new supply was introduced in 1899, and it is in good condition to-day, so that it would be easy to get from three to four million gallons a day from Little Quittacas Pond into the Acushnet Reservoir through that ditch.

REPORT OF COMMITTEE ON UNIFORM STATISTICS.

JOSEPH E. BEALS, GEORGE F. CHACE, JOHN C. WHITNEY, *Committee.*

[*Presented January 8, 1902.*]

Mr. Joseph E. Beals, chairman of the Committee on Uniform Statistics, presented the following report : —

The Committee on Uniform Statistics, after spending considerable time upon the subject, although there were but two or three conferences of the whole committee, would recommend for adoption by the Association the form which has been in use for the last fifteen years, with a few alterations. The report, which we herewith submit, is practically the embodiment of the memoranda presented by the Editor of the JOURNAL at one of our conferences. Our report was written last September, but it failed to reach the Portland Convention. The writing of it was left to me, and, after I had prepared it, I sent it to the second member of the committee, Mr. Chace; and he sent it to the third member, Mr. Whitney; and Mr. Whitney says he sent it then to the Secretary of the Association, but it has disappeared from sight somewhere. The best I can do, therefore, in the way of a report now is to present to you the form which our Editor has had printed, and which embodies the ideas that were suggested when he was present at one of the meetings of the committee.*

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* Since the January meeting, the original report of the Committee has been found. It is as follows: —

SEPTEMBER 16, 1901.

To the Officers and Members of the New England Water Works Association:

GENTLEMEN, — The Committee appointed by you to consider the question of the preparation of statistics respectfully report that they have given the subject somewhat careful consideration, and would recommend that the old form which has been in use since the formation of the Association be, in the main, continued, with such few alterations as new and changed conditions seem to make advisable. For this purpose we have taken the blank schedule sent out by Mr. Sherman, our Editor, and noted such alterations as we deem advisable.

We would also advise that another section be added, covering information from plants which are making chemical and bacteriological examinations of water.

Respectfully submitted,

JOSEPH E. BEALS,
GEO. F. CHACE,
J. C. WHITNEY, } *Committee.*

I may say that we have received communications from eight or ten water organizations and statistical organizations asking for information, and in reply have sent to most of them the printed form that we have heretofore used. In very few cases have we received any suggestions from these other organizations, but in almost every instance the request has been made by them for us to furnish suggestions if we had any to make. We, therefore, present our own form, which we have used in the past, as the form which we recommend for us in the future, with a few changes, to some of which I will briefly call attention.

Under the head of "Pumping" there have been some changes in phraseology. For instance, "Description of Fuel Used" specifies "*a*. Kind," "*b*. If coal, what brand?"—the old headings were "*a*. Anthracite" and "*b*. Bituminous"—"*c*. Average price of coal per gross ton, delivered." We put it gross ton, as it stood in the former recommendation, but if I were going to alter that I should say, "per net ton," as I think 2 000 pounds is easier reckoning than 2 240. Then we insert 4*a*, "Amount of other fuel used," for we find that in some water works they use other fuels. Gasolene is being used quite largely, and naphtha, and in one or two places sawdust is used as fuel. I cannot from recollection specify all the alterations we have made under the head of "Pumping," but there are a few others.

Under the head of "Financial," we have modified the Maintenance table so as not to call for reports giving statistics for receipts for water for manufacturing purposes. We found when we came to tabulate the figures of receipts for manufacturing purposes that there was so much difference in the practice, that it was perhaps better to leave the word "manufacturing" out and simplify the rate; and we have therefore called for water rates by fixture, water rates by meter, and net receipts for water; and then for miscellaneous receipts for rent, repairs, sales, etc., and then for the total from consumers. Then come the receipts from public funds, F, G, H, I, and J,—hydrants, fountains, street watering, public buildings, and general appropriations. Probably in a good many cases the first four would be put under the head of "General Appropriations." I know that in the works that I represent we make a lump sum of those as a total from public funds. We found in tabulating that some of the works make a practice of carrying a balance forward, while others cover their balances into the town or city or district treasuries; but,

inasmuch as some of them bring forward a balance from year to year, we have provided a place for that in the table.

We have made very few changes under the head of "Financial—Construction." Instead of special rates of interest, we provide for the average rate of interest, and under "Expenditures" we have put in "Extension of meters." Under "Consumption" I think we suggest no change. Under the head of "Distribution," in the old form item No. 7 called for the number of leaks, and some cities returned the number per mile, and some the total number of leaks they actually had, so that in making up the statistics the Editor found it was sometimes quite difficult to tell which was meant. For instance, if a works reported, as some did, only one leak, it was difficult to tell whether it was one leak per mile or one leak in the whole system. I recollect that in the operation of my works during one year I not only did n't have one leak per mile, but not one leak in the whole system even. Then under "Services" we have had added one or two things, for example, No. 27, "Percentage of services metered," and No. 28, "Percentage of receipts from metered water." No. 23, "Average length of service," would be the total length of services divided by the number of services.

BLANK FORM FOR

SUMMARY OF STATISTICS.

Draw a line through items not applicable to the works under consideration, leaving the number on the items used *unchanged*.

Pumping. — (6.) Cross out "with" or "without," to indicate whether slip has been taken into consideration.

(8.) The dynamic head is indicated by pressure gage at pumping engine.

(10.) Only one formula for duty is here presented. It is hoped that for the sake of uniformity this formula will be strictly followed in this summary. Other methods may, if desired, be used in the body of the report.

(11, 12.) The pumping station expenses for this statement are to include only *Cost of Fuel*, *Salaries*, *Oil*, *Waste*, *and other supplies*, and *Repairs on Machinery and Boilers.*

(13, 14.) Item CC under *Financial* is the amount to be used in obtaining these figures.

Special Notice. — Please send a copy of each report in which a summary of statistics appears to the New England Water Works Association, 715 Tremont Temple, Boston.

SUMMARY OF STATISTICS

For the year ending..................

In form recommended by the New England Water Works Association.

...WATER WORKS.

....	....	....
(City or Town.)	(County.)	(State.)

Population by Census of 19 ,..................................

Date of Construction,..

By whom owned,..

Source of supply,..

Mode of supply,..
(Whether gravity or pumping.)

PUMPING.

1. Builders of Pumping Machinery,..
2. Description of Fuel used,
   - *a.* Kind,...........................
   - *b.* If coal, what brand?.............................
   - *c.* Average price of coal per gross ton, delivered, $ ....
   - *d.* Percentage of ash, ...
   - *e.* Wood, price per cord, $............................
   - *f.* Other fuel, price, $..........................
3. Coal consumed for the year,............................lbs.
4. [Pounds of wood consumed] $\div 3 =$ equivalent amount of coal,......................lbs.

4*a*. Amount of other fuel used,.............................

5. Total equivalent coal consumed for the year $=$ (3) $+$ (4),...........................lbs.
6. Total pumpage for the year,.................................. gallons, $\left\{ \begin{matrix} \text{with} \\ \text{without} \end{matrix} \right\}$ allowance for slip.
7. Average static head against which pumps work,.. ....feet.
8. Average dynamic head against which pumps work, ... feet.
9. Number of gallons pumped per pound of equivalent coal (5),............................
10. $$\text{Duty} = \frac{\text{gallons pumped (6)} \times 8.34 \text{ (lbs.)} \times 100 \times \text{dynamic head (8)}}{\text{Total fuel consumed (5)}} = \ldots\ldots\ldots\ldots$$

Cost of pumping, figured on pumping station expenses, viz., $.......................

11. Per million gallons pumped, $ ....
12. Per million gallons raised one foot (dynamic), $............................

Cost of pumping, figured on total maintenance, viz., $ ....

13. Per million gallons pumped, $...........................
14. Per million gallons raised one foot (dynamic), $............................

FINANCIAL.

MAINTENANCE.

Receipts.			Expenditures.		
Balance brought forward		$	AA. Management and repairs		$
From Consumers:			BB. Interest on bonds		
A. Water rates, fixture,	$		CC. Total maintenance for year		$
B. Water rates, meter,			DD. Balance		
C. Net receipts for water, (A) + (B),	$				
D. Miscellaneous (rent, repairs, sales, etc.)					
E. Total from consumers		$			
From Public Funds:					
F. Hydrants	$				
G. Fountains					
H. Street watering					
I. Public buildings					
J. Gen'l appropriations					
Total from public funds					
K. Gross receipts from all sources		$	K. Total		$

FINANCIAL.

CONSTRUCTION.

Receipts.			Expenditures.		
Q.	From balance of previous year	$....................	FF.	Extension of mains	$....................
R.	,, Bonds issued	....	GG.	Extension of services	....
S.	,, Appropriations from tax levy	....	HH.	Extension of meters	....
T.	Transferred from maintenance account	....	II.	Special (reservoirs, pumps, etc.)	....
U.	From other sources	....	JJ.	Total construction for year	$....................
			KK.	Balance	....
V.	Total	$....................	V.	Total	$....................

W. Net cost of works to date . . . . . $..................

X. Bonded debt at date . . . . . . $..................

Y. Value of sinking fund at date . . . . . $..................

Z. Average rate of interest,.................. per cent.

CONSUMPTION.

1. Estimated total population at date,..
2. Estimated population on lines of pipe,.................................. ....
3. Estimated population supplied,...
4. Total consumption for the year,................................gallons.
5. Passed through meters.................................gallons.
6. Percentage of consumption metered,................................
7. Average daily consumption,...............................gallons.
8. Gallons per day to each inhabitant (1), ...
9. Gallons per day to each consumer (3),.................................
10. Gallons per day to each tap (taps in use),...............................

DISTRIBUTION.

MAINS.

1. Kind of pipe,....................................
2. Sizes, from..........inch to .... inch.
3. Extended..............feet during year.
4. Discontinued.......feet during year.
5. Total now in use,....................miles.
6. Cost of repairs per mile, $.............
7. Number of leaks per mile,................
8. Length of pipes less than 4 inches diam.,......................miles.
9. Number of hydrants added during year (public and private),..........
10. Number of hydrants (public and private) now in use,.....................
11. Number of stop gates added during year,.............. ......
12. Number of stop gates now in use, ...
13. Number of stop gates smaller than 4-inch,......................
14. Number of blow-off gates,..... ....
15. Range of pressure on mains at center of town,...........lbs. to..........lbs.

SERVICES.

16. Kind of pipe,...................... .. ..
17. Sizes,...................... .....
18. Extended, ... feet.
19. Discontinued,............ ....feet.
20. Total now in use,................miles.
21. Number of service taps added during year,..........................
22. Number now in use,........... ....
23. Average length of service, ... feet.
24. Average cost of service for the year, $ ....
25. Number of meters added, ...
26. Number now in use,.......................
27. Percentage of services metered,.........
28. Percentage of receipts from metered water (B ÷ C), ...
29. Number of motors and elevators added, ...
30. Number now in use,.................. ....
31. Number of standpipes for street watering, ...

DISCUSSION.

Mr. R. C. P. Coggeshall.* I suppose the number of leaks per mile you would have to express in decimal. That is, if there were one hundred miles of mains in a system and there were twenty-five leaks, it would be twenty-five hundredths of a leak for each mile.

Mr. Beals. That is what it would be, twenty-five hundredths of a leak per mile.

Mr. Coggeshall. I don't see any other way to express it.

Mr. Beals. We changed that because some report the number of leaks during the year and some report the number of leaks per mile. Of course, twenty-five hundredths of a leak would be a small figure, but it would make the amount of leakage clearer than if there were stated to be twenty-five leaks and you did n't look to see that there were one hundred miles of pipe.

Mr. M. N. Baker† (*by letter*). A committee of the Central States Water Works Association has recommended the use of the present New England schedule, pending further developments. The American Water Works Association, at its last meeting, appointed a committee to coöperate with others in this matter. A committee of the American Society of Municipal Improvements several years ago submitted a schedule for water-works statistics.

It is now hoped that by next spring the various committees named above, together with committees from the National Municipal League and the American Economic Association, may agree upon a common schedule. The chief difficulty is to devise a summary of statistics brief and simple enough for general adoption, yet sufficiently comprehensive to include many of the details of water-works practice eagerly sought by the water-works officials of the present day.

It has been suggested that two schedules be provided — a sort of longer and shorter catechism. Why could not the original New England schedule serve as the shorter, and that of the American Society of Municipal Improvements be adopted as the longer summary? It has been urged that the Municipal Improvement schedule contains everything that is in the New England, and much besides. I have compared the two with some care and find that this is not far from the truth. Certainly it would be an easy matter to insure exact correspondence, except in the matter of length.

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* Superintendent of Water Works, New Bedford, Mass.

† Associate Editor, *Engineering News*.

I hope it may prove possible for the New England Water Works Association to preserve its old schedule practically unchanged for some months longer, until there has been one more attempt to bring the various societies together. If that attempt does not succeed I shall then recommend the several committees of which I am a member to adopt the then existing schedule of the New England Water Works Association. Of course there can be no harm in making a few minor changes in the schedule meanwhile, so long as they leave the general plan and scope of the New England schedule open, and do not commit it to seeming independence of action.

If it seems wise to the other members of the Association, I suggest: That the present committee be continued, with power to coöperate with committees of other societies in an effort to secure the adoption of a uniform summary of water-works statistics suitable for annual reports, and ultimately at least a nearer approach to uniformity in water-works accounting.

MR. BEALS. The committee recognized that possibly the Association might desire to add one or two items regarding purification and filtration of waters, and the chemical and perhaps biological examinations. As I remember it now, that was recommended in the report which was prepared. I want to say further that our efforts have been to simplify these statistics rather than to add complications. Many of our members make up their reports at about this time of the year, which is a very busy season with them, and it sometimes would require more labor than we feel we have time to put into it, especially if we should add everything that some people, whom I may call cranks on the subject of statistics, want to have added to the statistics. We could very easily double the length of these tables by adding everything we could think of to ask for in the way of statistics, but I fear the result would be that we would find we would n't get anything answered. The fact now is that, up to the beginning of 1900, we were only able to get twenty-eight reports, and those were not all from our own members, either; but they were all we could get from reported statistics in the annual reports. Since then our Editor, by personal correspondence and sending out blanks similar to this, has succeeded in getting sixty reports. But the fact that he could only get sixty shows either that there is a desire not to make such reports, or else that our members have n't time to fill in the information. We hope that by making the thing very simple we may be able to get from the busy members better returns

than we would if we made the blank so extended and so elaborate that gentlemen would merely look at it and throw it one side.

Mr. C. W. Sherman.* So many members had gone out near the close of our last meeting, that it may be well for me now to call attention to the fact that at my request, as I wanted to send the blanks out so that the superintendents could use them in making up their returns for the past year, the meeting then endorsed the use of this printed form for summarizing the reports for 1901. Of course we did not accept it beyond that.

Mr. Coggeshall. I should like to ask Mr. Beals, the chairman of the committee, if he does not think it would be a good idea to add Mr. Baker to the committee, as he seems to have made a special study of this subject, and then continue the committee for a while longer.

Mr. Beals. As Mr. Baker is a member of this organization, as well as of several others of a kindred nature, I think it might aid in bringing about a unity of sentiment if he were either added to the committee or substituted for some one of the members. I should be perfectly willing that the committee be discharged and a new one be appointed with Mr. Baker at the head of it.

Mr. Dexter Brackett. To put this in some concrete form, I will move, as I believe that the subject is one of importance, and in view of the fact that it may be wise to include some other statistics, that the committee be continued, with the addition of Mr. M. N. Baker and of our Editor, Mr. C. W. Sherman, as members, to make such further investigation as they may deem expedient.

Adopted.

* Editor, Journal of the N. E. W. W. Association.

PROCEEDINGS.

December Meeting.

Young's Hotel, Boston, Mass.,
December 11, 1901.

Past President Horace G. Holden in the chair.

The attendance was as follows: —

Members.

Charles H. Baldwin, Lewis M. Bancroft, George W. Batchelder, Joseph E. Beals, James W. Blackmer, George Bowers, Dexter Brackett, Fred Brooks, George F. Chace, John C. Chase, Freeman C. Coffin, R. C. P. Coggeshall, J. W. Crawford, F. F. Forbes, W. E. Foss, F. B. French, F. L. Fuller, J. F. Gleason, Albert S. Glover, Amos A. Gould, J. A. Gould, Frank E. Hall, John O. Hall, L. M. Hastings, Horace G. Holden, J. L. Howard, E. W. Kent, Willard Kent, C. F. Knowlton, Edward S. Larned, Charles S. Lord, A. E. Martin, William E. Maybury, Leonard Metcalf, H. N. Parker, J. H. Perkins, Macy S. Pope, J. B. Putnam, W. H. Richards, W. W. Robertson, Harley E. Royce, Caleb M. Saville, Walter H. Sears, P. P. Sharples, Charles W. Sherman, H. O. Smith, Frederic P. Stearns, J. J. Sullivan, William F. Sullivan, Charles N. Taylor, Lucian A. Taylor, H. L. Thomas, R. J. Thomas, William H. Thomas, D. N. Tower, W. H. Vaughn, W. W. Wade, William Wheeler, John C. Whitney, G. E. Wilde.

Associates.

The George F. Blake Mfg. Co., by A. F. Hall; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Chadwick-Boston Lead Co., by A. H. Brodrick; Chapman Valve Co., by Edward F. Hughes; Charles A. Claflin; Coffin Valve Co., by H. L. Weston; M. J. Drummond, by Walter E. Drummond; Garlock Packing Co., by Horace A. Hart; Hersey Mfg. Co., by Albert S. Glover; Henry F. Jenks; Lead-Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by W. H. Van Winkle; Sumner & Goodwin Co., by F. D. Sumner; United States Cast Iron Pipe and Foundry Co., by L. R. Lemoine; Walworth Mfg. Co., by R. S. Mitchell; R. D. Wood & Co., by E. F. Krewson.

GUESTS.

H. V. Macksey, Boston Water Works, Boston, Mass.; L. S. Doten, C. E., Boston, Mass.; Samuel C. Hunt, Member Water Board, New Bedford, Mass.; W. C. Livermore, Holyoke, Mass.; M. J. Dowd and H. C. Taft, Water Commissioners, Lowell, Mass.; James T. Stevens, Water Commissioner, Braintree, Mass.; C. A. Donovan, Member Water Board, Lawrence, Mass.; H. C. Stillwell, Marion, Ohio; E. J. Sanburg, Quincy, Mass.; E. P. Walters, A. F. Bridgman, Metropolitan Water Works, Boston, Mass.; F. A. Morrison, W. H. Greenwood, F. W. Blanchard, Boston, Mass.; L. P. Woods, Boston, Mass.; W. I. Edwards, Londonderry, N. S.

Edward S. Larned, C. E., Metropolitan Water Works, South Framingham, Mass., read a paper entitled "Swamp Drainage for Watershed Improvement." The paper was discussed by Horatio N. Parker, Biologist, Metropolitan Water Works; Walter H. Richards, Superintendent, New London; Charles W. Sherman, Assistant Engineer, Metropolitan Water Works; Edwin C. Brooks, Superintendent, Cambridge; R. C. P. Coggeshall, Superintendent, New Bedford, and Leonard Metcalf, Civil Engineer, Boston.

The report of the Committee on "Standard Specifications for Cast-iron Pipe" was presented by Mr. Freeman C. Coffin, chairman of the committee. Written communications discussing the report were received from Emil L. Nuebling, Engineer and Superintendent of the Water Department, Reading, Pa.; Frank A. McInnes, Assistant Engineer, Engineering Department, Boston, and Louis H. Knapp, Engineer, Buffalo Water Works.

There was also oral discussion by L. R. Lemoine, representing the United States Cast Iron Pipe and Foundry Co.; Edmund F. Krewson, representing R. D. Wood & Co.; W. I. Edwards, representing the Montreal Pipe and Foundry Co.; Dexter Brackett, Engineer Distribution Department, Metropolitan Water Works, and also a member of the committee; Walter H. Richards, Superintendent, New London; H. V. Macksey, of the Boston Water Works; J. A. Gould, Chief Engineer of the Brookline & Dorchester Gas Light Companies, and Frank L. Fuller and E. H. Gowing, Civil Engineers.

On motion of Mr. Robert J. Thomas it was voted to continue the discussion of the report at the January meeting.

SUMMARY OF STATISTICS.

MR. CHARLES W. SHERMAN. Before the meeting adjourns, as it is evidently too late to receive the report of the Committee on Uni-

form Statistics this afternoon. I should like to call attention to one matter, which will take but a moment of your time, in that connection. I have anticipated the acceptance of what, perhaps, I might call the preliminary report of the committee, to the extent of having blank forms printed for use in preparing the annual reports for 1901. If we wait until another meeting to endorse the use of these, it will be too late for many of the members. I might say, as many of you know, that I was in consultation with the committee at its meeting before the Portland Convention, and at that time they decided to recommend certain slight changes in the form now in use, and these blanks which I have had printed embody those recommendations. I do not wish to have you adopt the form offhand in this way for indefinite future use; but I do wish that this meeting would pass a vote authorizing its use for the current year, as it is but a slight modification of the form previously used. I will make that as a motion, that the Association endorse the use of the form now printed, including the recommendations of the committee, for the reports of 1901.

Adopted.

Mr. R. J. Thomas. I wish to state for the information of the members who may wish to buy pipe before the specifications are settled upon, that if they will consult the pages of the Journal they will find the advertisements there of foundrymen who are willing to do work as required by these specifications which have been submitted.

Adjourned.

PROCEEDINGS.

Annual Meeting.

Young's Hotel,
Boston, January 8, 1902.

President Crandall in the chair.

The following members and guests were present: —

Members.

Lewis M. Bancroft, Roland D. Barnes, Joseph E. Beals, James F. Bigelow, George Bowers, Dexter Brackett, Fred. Brooks, L. Z. Carpenter, George Cassell, George F. Chace, G. L. Chapin, John C. Chase, Freeman C. Coffin, R. C. P. Coggeshall, F. H. Crandall, J. W. Crawford, M. F. Collins, L. E. Daboll, A. O. Doane, H. A. Fiske, F. F. Forbes, J. F. Gleason, Albert S. Glover, J. A. Gould, E. H. Gowing, J. O. Hall, J. C. Hammond, Jr., D. A. Harris, H. G. Holden, E. W. Kent, Willard Kent, George A. Kimball, James W. Locke, Frank E. Merrill, Leonard Metcalf, Macy S. Pope, C. E. Riley, H. E. Royce, W. H. Sears, E. M. Shedd, Charles W. Sherman, J. Waldo Smith, George H. Snell, George A. Stacy, F. P. Stearns, William F. Sullivan, C. N. Taylor, L. A. Taylor, D. N. Tower, George W. Travis, W. H. Vaughn, William W. Wade, William Wheeler, George E. Wilde, F. B. Wilkins.

Associates.

Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet and H. J. Burroughs; Chapman Valve Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by Albert S. Glover; Lead-Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; National Meter Co., by J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; Union Water Meter Co., by J. P. K. Otis.

Guests.

H. V. Macksey, Boston Water Works, Boston, Mass.; T. J. Burke, Water Commissioner, Brookline, Mass.; G. S. Hedge, Boston, Mass.; Charles Donovan and A. H. Robinson, Water Commissioners, Lawrence, Mass.

The following applicants were elected to membership, having been recommended by the Executive Committee: —

Resident Members.

Leonard S. Doten, Boston; James F. Stevens, Brockton, Chairman Brockton Water Board.

Non-Resident Members.

Thomas Archibald MacLean, Charlottetown, P. E. I.; James M. Betton, New York.

Associate.

Montreal Pipe Foundry Co., Ltd., Manufacturers of Cast-Iron Water Pipes and Special Castings, Londonderry, N. S.

The President appointed Messrs. D. N. Tower and C. N. Taylor as tellers to count the ballots for officers for the year 1902.

PRESIDENT'S ADDRESS.

President F. H. Crandall, of Burlington, Vt., then delivered the following address: —

With matters of considerable interest and importance pressing for attention, I will take no more of your time than necessary to briefly touch upon the subjects upon which it has become customary to expect a word from a retiring president.

Before taking up the perfunctory part of the program, I wish to thank you for the honor conferred upon me a year ago, as well as for your forbearance and assistance since.

The hope expressed by our President at the Burlington Convention, in 1895, that each of his successors might, in turn, enjoy the pleasure then accorded him, of reporting the Association larger, stronger, and more powerful for good than ever before, has been amply gratified. We can again congratulate ourselves on the completion of a year of wonted growth and activity.

The results of the provision, made at the Rutland Convention, for the improvement of the JOURNAL, we have all had an opportunity to see in the JOURNAL itself, though I doubt if any of us half appreciate the untiring diligence of our able Editor. The index which Mr. Sherman has under way, when put up in card form, and kept at headquarters, up to date, will materially add to the value of

headquarters. I had hoped to approve a bill for this card index, but I understand that though, like most good things, slow in coming, it is on the way.

The work of the past season I will not attempt to review. Matters of interest and importance have occupied our attention at each meeting, and the indefatigable efforts of our genial Secretary have resulted in placing in his hands several more interesting and instructive papers than there has thus far been opportunity to present at the meetings of the Association.

Our financial condition is, according to the Micawberian standard, one of perfect happiness. Our expenditures have been less than our receipts, and the balance, to-day reported by our Treasurer, is less than that of his last report only because we have paid several bills incurred during preceding years as well as all bills contracted during the year just past.

Death has, during the past year, claimed eight of our members: William H. Laing, Superintendent and Secretary, Racine Water Company, Racine, Wis.; Samuel G. Stoddard, Jr., Superintendent and Engineer, Bridgeport Hydraulic Company, Bridgeport, Conn.; Patrick F. Crilly, Superintendent, Woburn Water Works, Woburn, Mass.; Jo H. Linsley, Director Vermont State Laboratory, Burlington, Vt.; Henry W. Rogers, Haverhill, Mass.; John H. Decker, Brooklyn, N. Y.; James M. Battles, Superintendent, St. Mary's House for Sailors, East Boston, Mass.; Arnold H. Salisbury, Superintendent, Lawrence Water Works, Lawrence, Mass.

To the untiring energy and persistence of Dr. Jo H. Linsley is due the recent notable advancement in matters pertaining to the public health of Vermont.

Henry W. Rogers was a founder and past-president of the Association.

John H. Decker was a founder of the American Water Works Association.

The yeoman service rendered by James M. Battles, here at home, where charity and missionary work should begin, will long be remembered in this port.

A. H. Salisbury, owing to his general temperament and frequent attendance upon our meetings, was probably the most well-known among us of those who have been called to the other shore. As at this time we devote a brief space to those who, during the year past, have passed away, we may derive some comfort and encouragement

from the knowledge that "no life can be pure in its purpose and strong in its strife, and all life not be purer and stronger thereby."

The water supply engineer of to-day has a delicate and thankless task on his hands. The demand for the learned and intricate is not alone made upon the medical profession, though the case of the lady seeking to learn why some people are born blind is a most striking example of the prevalent demand. Many of you, no doubt, recollect the reply of the learned oculist. He said, "I suppose, madam, that the phenomenon of which you speak is the result of the parties in question having come into this world physically incapacitated to perceive the light," whereupon the good lady gave expression to her appreciation of a physical education, remarking that she had asked her husband the same question many times, and all that she could get out of him was, "Kase they is." It is up to the engineering profession to cause an engineering education to be equally appreciated.

If the supply be short because more water is wasted than can be used, public opinion requires that the remedy be sought in increased pumping facilities, or in elaborate plans for an increased supply, rather than in the conservation of the supply at hand.

When considering the huge discrepancy usually existing between the pumping record and the amount of water accounted for, public opinion requires that evaporation, the error of the meter, the aggregate of a vast number of small leaks, and, perhaps, in a general way, losses from other causes, be marshaled in explanation of what is, by popular fallacy, designated a strange and unaccountable condition.

Public opinion in these matters, striving for an intricate and learned explanation of a plain and simple proposition, stands in much the same position as did the Maine editor, who sought to explain, in a supernatural manner, the advent of his first-born. He said: —

"One night as old St. Peter slept,
He left the doors of heaven ajar,
When through a little angel crept,
And came down with a falling star.

"One summer, as the blessed beams
Approached, my blushing bride
Awakened from some pleasant dreams,
And found the little angel by her side.

"God grant but this, I ask no more,
That when he leaves this world of pain,
He'll wing his way to that bright shore,
And find the path to heaven again."

And yet no one has come forward to set public opinion right.

You, no doubt, remember that John G. Saxe, taking issue with the down-east editor, stated the plain, unvarnished facts in regard to that little every-day occurrence, in a manner so straightforward and convincing as to leave no room for argument. He said, speaking for St. Peter: —

"Full eighteen hundred years or more,
I've kept my doors securely fast,
There has no little angel strayed
Or recreant through the portal passed.

"I have not slept, as you suppose,
Nor left the gates of heaven ajar,
Nor has a little angel strayed
Or gone down with a falling star.

"Go ask that blushing bride, and see
If she don't frankly own and say,
That when she found that angel babe,
She found it in the good old way.

"God grant but this, I ask no more,
That should your numbers still enlarge,
You'll not do as you've done before,
And lay it to old Peter's charge."

REPORT OF EXECUTIVE COMMITTEE.

President Crandall. I had not understood until this moment that I was expected to make a report for the Executive Committee, but inasmuch as I am now informed that I am, I will say that the affairs of the Association appear to the Executive Committee, so far as we have consulted with each other, to have been carried on during the past year in a satisfactory and businesslike manner. The only suggestions we have to make are that in the future the report of the officer who is in position to know in regard to the matter should include a statement of the liabilities and assets of the Association; and that the place for holding the annual convention should be fixed upon at as early a date as possible.

REPORT OF THE TREASURER AND FINANCE COMMITTEE.

Mr. Lewis M. Bancroft, Treasurer, then submitted his report. On motion of Mr. Coggeshall the reading of the details was dispensed with. The report is as follows: —

LEWIS M. BANCROFT, Treasurer, *in account with*

RECEIPTS.

1901.				
January 1.	Balance on hand			$2 108.24
16.	Received of Willard Kent, Secretary		$173.50	
February 9.	" " " " "		301.62	
18.	" " " " "		211.25	
March 5.	" " " " "		216.00	
22.	" " " " "		61.95	
April 4.	" " " " "		125.23	
May 7.	" " " " "		86.90	
13.	" " " " "		172.80	
31.	" " " " "		119 50	
June 15.	" " " " "		172.95	
28.	" " " " "		93.80	
July 10.	" " " " "		379.50	
17.	" " " " "		354.00	
August 16.	" " " " "		359.00	
October 9.	" " " " "		233.40	
November 13.	" " " " "		153.78	
21.	" " " " "		360.80	
December 2.	" " " " "		193.95	
1902.				
January 8.	" " " " "		424.45	4 193.88
1901.				
August 16.	Dividend, Peoples Savings Bank			43.72
October 9.	Interest on deposit, National Bank			.95
				$6 346.79

EXPENDITURES.

1901.		
January 4.	Bacon & Burpee, reporting Nov. and Dec., 1901, meetings	$27.50
	Samuel Usher, printing December, 1900, JOURNAL	406.20
12.	Willard Kent, salary and expenses to January 1, 1901	29.17
15.	D. Gillies' Sons, printing	18.55
	Association of Engineering Societies, cuts	2.75
	Charles W. Sherman, salary and expenses to January 1	30.57
16.	Francis L. Pratt, music at January meeting	20.00
22.	J. M. Ham, salary and expenses to January 15	26.76
	Thomas P. Taylor, stereopticon, January 9	10.00
February 15.	Hub Engraving Co., plates	42.60
	Hobbs & Warren Co., letter book and cards	1.95
	D. Gillies' Sons, stamped envelopes and printing	124.25
21.	Francis L. Pratt, music, February meeting	20.00
	J. M. Ham, salary and expenses to February 15	32.27
	Olmsted Bros., illustrations for paper at Rutland	20.00
27.	L. M. Bancroft, revenue stamps	2.00
March 6.	Boston Society of Civil Engineers, rent to February 28	100.00
	Hub Engraving Co., plates	8.52
13.	W. N. Hughes, printing membership list, etc.	89.58
	D. Gillies' Sons, printing	3.25
	Samuel Usher, printing	1.50
	Hobbs & Warren Co., cards	.40
19.	Francis L. Pratt, music, March meeting	20.00
21.	Samuel Usher, printing March JOURNAL	262.30
25.	J. M. Ham, salary and expenses to March 15	28.79
April 4.	Willard Kent, salary and expenses to April 1	101.25
	Charles W. Sherman, salary and expenses to April 1	84.75
29.	Bacon & Burpee, report of Jan., Feb., and March meetings	80.25
	Robert J. Thomas, advertising agent, to April 1	41.75
	D. Gillies' Sons, printing	5.02
May 16.	J. M. Ham, salary and expenses to April 15	26.75
	Hub Engraving Co., cuts	25.08
	Hobbs & Warren Co., book and cards	3.35
	Samuel Usher, printing	13.00
23.	J. C. Whitney, expenses, 1899	70.78
June 18.	W. N. Hughes, envelopes for JOURNALS	45.00
	D. Gillies' Sons, printing circulars	4.75
	Boston Society of Civil Engineers, rent to May 31	100.00
	J. M. Ham, salary and expenses to June 15	56.74
July 22.	Samuel Usher, printing June JOURNAL	267.05
	Charles W. Sherman, salary and expenses to July 1	82.85
	Willard Kent, salary to July 1	50.00
	J. M. Ham, salary and expenses to July 15	26.91
	Robert J. Thomas, advertising agent, to July 1	61.40
	Hobbs & Warren Co., cards	.46
August 27.	Hub Engraving Co., cuts	1.47
	D. Gillies' Sons, receipt book and envelopes	33.50
September 17.	Charles W. Sherman, salary and expenses to October 1	78.34
23.	J. M. Ham, salary and expenses to September 15	50.80
October 10.	J. M. Ham, salary and expenses to October 15	47.03
	D. Gillies' Sons, postal cards and printing	24.25
	Boston Society of Civil Engineers, rent to August 31	100.00
	Willard Kent, salary and expenses to October 1	73.27
19.	Robert J. Thomas, advertising agent, to October 1	70.25
November 14.	D. Gillies' Sons, printing	4.25
	W. N. Hughes, printing	5.25
	J. M. Ham, salary and expenses to November 15	27.01
	Samuel Usher, printing September JOURNAL	353.25
	Bacon & Burpee, report of Annual Convention	45.00
December 20.	Hobbs & Warren Co., stationery	2.25
	W. N. Hughes, binding and cards	15.00
	J. M. Ham, salary and expenses to January 1, 1902	44.34
	Boston Society of Civil Engineers, rent to November 30	100.00
	Hub Engraving Co., plates	25.81
	Francis L. Pratt, music, December meeting	20.00
	Willard Kent, salary and expenses to January 1, 1902	81.00
	Charles W. Sherman, salary and expenses to January 1, 1902	80.00
	Thomas P. Taylor, stereopticon, December meeting	10.00
	Robert J. Thomas, advertising agent, to January 1, 1902	70.95
31.	D. Gillies' Sons, stamped envelopes and printing	88.10
	Bacon & Burpee, reporting November and December meetings	25.75
	Samuel Usher, printing December JOURNAL	307.75
	W. N. Hughes, billheads	5.00
	Henry F. Jenks, expenses, Committee on Exhibits of Associates	17.60
		$4 283.22

BALANCE ON HAND.

Cash	$424.45	
Deposit, Peoples Savings Bank, Worcester	1 293.42	
Deposit, Mechanics Savings Bank, Reading	300.00	
Deposit, First National Bank, Reading	45.70	2 063.57
		$6 346.79

Mr. Coggeshall. How does the balance compare with the balance at the date of the last report?

Mr. Bancroft. It is $44.67 less than at the date of the last report. There have been paid during the year bills contracted during the years 1899 and 1900, amounting to $70.78 and $514.74, respectively. The receipts for the year 1901 were $4 238.55, and the bills paid for the year 1901 were $3 697.70, leaving a balance of receipts over expenditures for the year of $540.85. I know of no outstanding bills which we owe.

On motion of Mr. Brackett, it was voted to accept and print the report of the Treasurer.

Mr. J. W. Crawford, for the Finance Committee, stated that the report of the Treasurer had been examined and found to be correctly cast, with proper vouchers for all expenditures, and the balance correct as stated.

On motion of Mr. Brackett, the report of the Finance Committee was accepted.

REPORT OF THE SECRETARY.

The Secretary, Mr. Willard Kent, submitted the following: —

Mr. President and Gentlemen of the New England Water Works Association, — I have the honor to submit the following report as Secretary: —

Statistics Relating to Membership for Year Ending December 31, 1901.

January 1, 1901.	Total membership			606

ACTIVE MEMBERS.

January 1, 1901.	Total active membership		530
	Withdrawals:		
	Resignations	8	
	Dropped	61	
	Died	8	77
			453
	Initiations:		
	January	6	
	February	1	

	March	7		
	June	9		
	September	12		
	November	5		
	December	0	40	493

HONORARY MEMBERS.

January 1, 1901.	Honorary members	4	
January 1, 1902.	Honorary members		4

ASSOCIATES.

January 1, 1901.	Total associate membership		72	
	Withdrawals:			
	Resigned	9		
	Dropped	9	18	
			54	
	Initiations:			
	January	1		
	February	1		
	March	0		
	June	1		
	September	1		
	November	0		
	December	0	4	58
January 1, 1902.	Total membership			555

SUMMARY OF RECEIPTS OF THE NEW ENGLAND WATER WORKS ASSOCIATION FOR THE YEAR ENDING DECEMBER 31, 1901.

Dues	$1 759.00
Advertising	1 750.50
JOURNALS sold	315.68
Initiation	266.00
Sundry	75.95
Subscriptions	26.75
Total	$4 193.88

SUMMARY OF EXPENSES OF THE NEW ENGLAND WATER WORKS ASSOCIATION FOR YEAR ENDING DECEMBER 31, 1901.

JOURNAL	$1 366.55
Stationery and printing	414.78
Rent	400.00
Assistant Secretary	312.50

Editor	300.00
Expenses	259.30
Advertising Agent	244.35
Secretary	200.00
Stenographer	151.00
Music	80.00
Stereopticon	20.00
Slides	20.00
Total	$3 768.48

Amount of Receipts above Expenditures........ $425.40

At the present time there is due the Association $520.50 for annual dues, $408.75 for advertising, and $10.75 for sundry items, such as reprints, etc., making a total of $940. I know of no outstanding bills against the Association.

Respectfully submitted,

(Signed) WILLARD KENT,
Secretary.

On motion of Mr. Coggeshall, the report was accepted and ordered printed in the JOURNAL.

Mr. Charles W. Sherman, Editor, then read his report.

REPORT OF THE EDITOR OF THE JOURNAL.

BOSTON, January 1, 1902.

To the President and Members of the New England Water Works Association :

The following is a report for Volume XV of the JOURNAL, including the six issues from September, 1900, to December, 1901, and covering the nineteen months from June 1, 1900, to date.

Table No. 1 gives a detailed statement of the material in this volume of the JOURNAL; while Tables Nos. 2 and 3 show in detail the receipts and expenses, on account of the JOURNAL, for the nineteen months and for the year, respectively. The increase in the amount of advertising since the election of Mr. R. J. Thomas as Advertising Agent is worthy of note, as is also the fact that the net cost of the JOURNAL for the year 1901, as shown by Table No. 3, was nothing. It is to be noted that no part of the dues from members is included in the receipts.

TABLE No. 1.—STATEMENT OF MATERIAL IN VOLUME XV, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1900–01.

Number.	Date of Issue.	Number of Pages of: Papers.	Proceedings.	Volume Index, etc.	Total Text.	Advertisements.	Covers and Contents.	Inset Plates.	Membership List.	Total.	Cuts.
1	September, 1900..	93	3	...	96	20	5	4	...	125	3
2	December, 1900...	97	31	...	128	18	5	10	...	161	12
3	March, 1901........	63	11	...	74	22	5	11	48	160	9
4	June, 1901..........	61	7	...	68	28	4	7	...	107	4
5	September, 1901..	74	18	...	92	30	4	...	...	126	1
6	December, 1901...	70	2	14	86	30	4	5	...	125	...
	Totals.............	458	72	14	544	148	27	37	48	804	29

TABLE No. 2.—EXPENDITURES AND RECEIPTS ON ACCOUNT OF VOLUME XV, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1900–01.

Expenditures.		Receipts.	
Printing Journal	$1 848.88	Advertising	$2 338.00
Engraving, etc.	143.60	Sale of Journals	334.23
Postage on Journal	41.94	Sale of Reprints	30.20
Editor's Salary	475.00	Sale of Cuts	16.85
Advertising Agent, Com. .	244.35	Subscriptions	72.75
Copyright Fees	3.00		$2 792.03
Incidentals	36.76		
Reporting Meetings . . .	270.35		
Compiling Statistics, 1897–8–9	25.00		
Reprints of Papers	162.00		
Blank Forms for Statistics .	40.50	Excess of Expenditures . .	499.35
	$3 291.38		$3 291.38

TABLE No. 3.—EXPENDITURES AND RECEIPTS ON ACCOUNT OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, DURING 1901.

EXPENDITURES.		RECEIPTS.	
Printing Journal	$1 125.88	Advertising	$1 750.50
Engraving, etc.	78.40	Sale of Journals	315.68
Postage on Journal	31.94	Sale of Reprints	30.20
Editor	300.00	Sale of Cuts	16.85
Advertising Agent	244.35	Subscriptions	26.75
Copyright Fees	2.00		
Incidentals	13.25		
Reporting Meetings	151.00		
Reprints of Papers	105.00		
Blank Forms for Statistics	40.50		
	$2 092.32		
Excess of Receipts	47.66		
	$2 139.98		$2 139.98

As usual, fifty reprints of papers have been furnished to their authors without charge. Where a larger number were wanted, they have been supplied at cost. The expense to the Association for these reprints has averaged $4.69 for each paper.

The total cost of the illustrations for the volume has been $307.60, or 9.4 per cent. of the gross cost. This is somewhat less than in Volume XIV, where the percentage was 11.

The present circulation of the JOURNAL is,—

Members	555
Subscribers	47
	602

Exchanges are made with fifteen periodicals.

As far as I know, there are no bills outstanding against the Association on account of the JOURNAL.

TABLE No. 4.

Comparison between Volumes XIV and XV, Journal of the New England Water Works Association.

	VOL. XV COMPLETE.	VOL. XV ONE YEAR.	VOL. XIV.
Edition (copies)	1 200	1 200	1 100
Numbers issued	6	4	4

Average membership	586	586	601
Pages of text	544	363	345
Pages of text per 1 000 members	926	618	600
Total pages, all kinds	804	536	485
Total pages per 1 000 members	1 370	913	832
GROSS COST:			
Total	$3 291.38	$2 194.26	$1 954.15
Per page	4.10	4.10	4.03
Per member	5.62	3.75	3.35
Per member, per 1 000 pages	6.99	6.99	6.91
Per member per 1 000 pages of text	10.31	10.31	9.71
NET COST:			
Total	$499.35	$332.90	$347.55
Per page	0.62	0.62	0.72
Per member	0.85	0.57	0.60
Per member per 1 000 pages	1.06	1.06	1.23
Per member per 1 000 pages of text	1.57	1.57	1.73

Respectfully submitted,

CHARLES W. SHERMAN,

Editor.

On motion of Mr. Cassell, it was voted that the report of the Editor be accepted and printed in the JOURNAL.

REPORT OF THE ADVERTISING AGENT.

The following report of Mr. Robert J. Thomas, Advertising Agent, was read by Mr. Sherman, Mr. Thomas being absent on account of illness.

LOWELL, January 1, 1902.

TO THE PRESIDENT AND MEMBERS OF THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — I herewith present the annual report of the Advertising Agent for the year 1901: —

The last issue of the JOURNAL for 1900 contained the following advertisers: National Meter Co., 1 page; Hersey Mfg. Co., 1 page; Thomson Meter Co., 1 page; Union Water Meter Co., 1 page; Neptune Meter Co., ½ page; The Peck Bros. & Co., ½ page; Walworth

Mfg. Co., 1 page; Chadwick Lead Works, 1 page, Boston Lead Mfg. Co., $\frac{1}{2}$ page; Lead-Lined Iron Pipe Co., $\frac{1}{2}$ page; R. D. Wood & Co., 1 page; Sweet & Doyle, 1 page; Ludlow Valve Mfg. Co., $\frac{1}{2}$ page; Emaus Pipe Foundry, $\frac{1}{2}$ page; United States Cast-Iron Pipe and Foundry Co., 1 page; Warren Foundry and Machine Co., $\frac{1}{2}$ page; M. J. Drummond & Co., $\frac{1}{2}$ page; Builders Iron Foundry, 2 half-pages; New York Filter Mfg. Co., $\frac{1}{2}$ page; E. P. Allis, 1 page; Perrin, Seamans & Co., $\frac{1}{2}$ page; Gould Packing Co., $\frac{1}{2}$ page; Lawrence Cement Co., $\frac{1}{3}$ page; making a total of $16\frac{5}{6}$ pages and an income of $1 135.

During 1901 the Edward P. Allis Co. and Sweet & Doyle refused to renew their advertisements, and the Boston Lead Mfg. Co. having been merged into the Chadwick-Boston Lead Works, another half-page was lost. With the foregoing exceptions all the advertisers renewed their contracts. The National Meter Co. increased their advertisement to 2 pages, the Neptune Meter Co. and the Lead-Lined Iron Pipe Co. increased their space from $\frac{1}{2}$ page to a full page each, and the following new advertisers were added: The Sumner & Goodwin Co., 1 page; A. P. Smith Mfg. Co., $\frac{1}{2}$ page; J. B. Campbell Brass Works, $\frac{1}{2}$ page; Eddy Valve Co., $\frac{1}{2}$ page; Kennedy Valve Mfg. Co., $\frac{1}{2}$ page; Coffin Valve Co., $\frac{1}{2}$ page; Rensselaer Mfg. Co., $\frac{1}{2}$ page; B. F. Smith & Bro., $\frac{1}{2}$ page; Barr Pumping Engine Co., 1 page; Eagle Oil and Supply Co., 1 page; International Steam Pump Co., 1 page; Jenkins Bros., 1 page; Garlock Packing Co., $\frac{1}{2}$ page; National Paint and Varnish Co., $\frac{1}{2}$ page; Boston Engineers' Supply Co., $\frac{1}{2}$ page; A. W. Chesterton & Co., $\frac{1}{2}$ page; Ashton Valve Co., $\frac{1}{4}$ page; Scannell & Wholey, $\frac{1}{4}$ page; Mason Regulator Co., $\frac{1}{4}$ page; and card advertisements from Davis & Farnum Mfg. Co., National Lead Co., and Thomas Watkins, making a total of $27\frac{1}{3}$ pages, earning $1 929, an increase in revenue from this source of $794.

That this amount can be still further increased is true beyond doubt, for there are a number of manufacturers and dealers in water-works supplies that are not as yet among our advertisers, and this notwithstanding the efficiency of the JOURNAL as a medium for reaching the six hundred members of the Association, most of whom buy thousands of dollars worth of supplies every year. But the members must make it an object for advertisers. By this I mean that you should give them consideration when you are about to purchase, and give them an opportunity to submit prices, etc. It seems as

though every member who has the interests of the Association truly at heart should do this.

Of the many advantages and benefits that we have to offer to our members the Journal is the greatest. To be sure, it is very enjoyable and instructive to attend our meetings in Boston and elsewhere, but later on if you want to profit by the papers you have heard here, you have to refer to the Journal. Then, again, there is the twenty-five per cent. of the members who are too far away to attend these meetings, — those in New York, New Jersey, Canada, and other places, — all the benefit they receive is from the Journal. Therefore, it is our duty to make the Journal as able, thorough, and efficient as possible, and, in doing this, the income from the advertising will be a material aid.

Hoping that the number of advertisers will keep on increasing, and that those now advertising with us will find it profitable to continue, this report is respectfully submitted.

ROBERT J. THOMAS,
Advertising Agent.

The President. The report of our Advertising Agent, with what has gone before it, shows conclusively that we made no mistake in the action taken at Rutland with regard to securing advertising matter for the Journal. There are many of us who, earlier in life, have experienced the difficulty of inducing schoolboys or college boys to recognize the necessity and the propriety of contributing to the support of their school or college papers by patronizing the advertisers in them; but it would seem that with us older men it should not be necessary to lay so great stress upon the propriety and advisability of so doing.

On motion of Mr. Stacy, the report of the Advertising Agent was accepted and ordered to be printed in the Journal.

ELECTION OF OFFICERS.

Mr. D. N. Tower, for the tellers of election, submitted the following report: —

Total number of votes, 168; 1 vote was blank, and 167 votes were cast for the official ballot as follows: —

President.

FRANK E. MERRILL, Somerville, Mass.

Vice-Presidents.

CHARLES K. WALKER, Manchester, N. H.
JAMES BURNIE, Biddeford, Me.
EDWIN C. BROOKS, Cambridge, Mass.
H. O. SMITH, Leicester, Mass.
WILLIAM B. SHERMAN, Providence, R. I.
J. C. HAMMOND, Jr., Rockville, Conn.

Secretary.

WILLARD KENT, Narragansett Pier, R. I.

Treasurer.

LEWIS M. BANCROFT, Reading, Mass.

Editor.

CHARLES W. SHERMAN, Boston, Mass.

Advertising Agent.

ROBERT J. THOMAS, Lowell, Mass.

Additional Members of Executive Committee.

PATRICK KIERAN, Fall River, Mass.
GEORGE A. STACY, Marlboro, Mass.
H. G. HOLDEN, Nashua, N. H.

Finance Committee.

A. W. F. BROWN, Fitchburg, Mass.
W. F. CODD, Nantucket, Mass.
J. W. CRAWFORD, Lowell, Mass.

The above-named gentlemen were declared elected. President Merrill was called to the chair by the retiring President, Mr. Crandall, and addressed the meeting as follows: —

Gentlemen, — In assuming the duties and responsibilities of the high office of President of the New England Water Works Association, I desire to take the opportunity to thank you heartily for the honor you have conferred upon me. I am sure that I shall have the cordial support which you have given to former presidents, and in return I pledge you my earnest efforts to do what I can to see that the Association does not fall from the high plane which it now occupies. [*Applause.*]

On motion of Mr. Coggeshall, the thanks of the Association were tendered to the retiring President and other officers.

Mr. Joseph E. Beals, Chairman of the Committee on Uniform Statistics, presented the report in behalf of that committee. A communication was read from Mr. M. N. Baker, and the committee was continued, with the addition of Mr. Baker and Mr. Charles W. Sherman as members, with instructions to make such further investigation as might be deemed expedient.

The discussion of the report of the Committee on Standard Specifications for Cast-Iron Pipe, presented at the December meeting, was continued by Mr. Leonard Metcalf and by Mr. Coffin and Mr. Brackett, members of the committee. Written discussions were also presented from the British Association of Water Works Engineers, Mr. George E. Manning, of New London, and others.

No action was taken upon the report of the committee.

Adjourned.

PROCEEDINGS.

FEBRUARY MEETING.

YOUNG'S HOTEL,
BOSTON, February 12, 1902.

President Frank E. Merrill in the chair.

The following members and guests were in attendance: —

MEMBERS.

L. M. Bancroft, Joseph E. Beals, James F. Bigelow, Dexter Brackett, E. C. Brooks, Fred Brooks, G. A. P. Bucknam, George Cassell, George F. Chace, John C. Chase, W. F. Codd, R. C. P. Coggeshall, M. F. Collins, L. E. Daboll, Charles R. Felton, R. J. Flinn, F. F. Forbes, William Paul Gerhard, H. F. Gibbs, J. C. Gilbert, Albert S. Glover, J. A. Gould, E. H. Gowing, William R. Groce, E. A. W. Hammatt, J. C. Hammond, Jr., George W. Harrington, D. A. Harris, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., H. G. Holden, E. W. Kent, Willard Kent, C. F. Knowlton, James W. Locke, W. E. Maybury, F. A. McInnes, T. H. McKenzie, Thomas McKenzie, F. E. Merrill, G. L. Mirick, F. L. Northrop, W. W. Robertson, E. M. Shedd, Charles W. Sherman, J. E. Smith, Sidney Smith, J. A. St. Louis, G. A. Stacy, Robert W. Taber, C. N. Taylor, H. L. Thomas, R. J. Thomas, D. N. Tower, W. H. Vaughan, W. W. Wade, C. K. Walker, F. B. Wilkins, G. E. Winslow.

ASSOCIATES.

Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by H. J. Burroughs and James Bowie; Charles A. Claflin & Co., by Charles A. Claflin; Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by James A. Tilden and Albert S. Glover; Kennedy Valve Co., by M. J. Brosman; Lead-Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Co., by H. F. Gould and S. F. Ferguson; National Meter Co., by J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by W. H. Van Winkle; Union Water Meter Co., by J. P. K. Otis, F. L. Northrop, and Charles L. Brown; United States Cast-Iron Pipe and Foundry Co., by John M. Holmes; R. D. Wood & Co., by Charles R. Wood.

GUESTS.

George H. Hart, Superintendent Water Works, Maynard, Mass.; George H. Partridge, *Engineering Record*, Boston, Mass.; George H. Leland, C. E., Providence, R. I.; John C. DeMello, Jr., New Bedford, Mass.; J. B.

Moore, Boston, Mass.; H. V. Macksey, Boston Water Works, Boston, Mass.; L. P. Stone, Natick, Mass.; Charles F. McCarthy, Worcester, Mass.; A. H. Robinson and E. L. Arundel, Water Commissioners, Lawrence, Mass.; W. Killan, Lawrence, Mass.; Clarence Goldsmith, North Andover, Mass.; John A. Connell, Charles A. Cook, J. Henry Gleason, H. J. Pratt, J. P. Wood, E. S. Murphy, H. C. Hunter, C. A. French, Louis P. Howe, E. Irving Sawyer, Walter P. Frye, O. H. Stevens, and Thomas P. Hurley, Water Commissioners and guests, Marlboro, Mass.

The Secretary read the following names of applicants for membership, the applications having been approved by the Executive Committee: —

For Resident Members.

Jeremiah H. Bartholomew, Ansonia, Conn.

A. M. Devereux, Castine, Me., Treasurer and Manager of the Castine Water Co.

Benjamin F. Goodnough, Brookline, Mass., Engineering Department Metropolitan Water Works.

Louis B. Cummings, Pittsfield, Mass., Clerk Board of Public Works.

George H. Hart, Maynard, Mass., Superintendent and Engineer of Maynard Water Works.

Andrew S. Merrill, Bath, Me., Superintendent Bath Division of Maine Water Co.

W. S. Wyman, Waterville, Me., Trustee Kennebec Water District.

Arthur B. Lisle, Providence, R. I., Treasurer of East Providence Water Co.

Edward Brown, Norfolk, Conn., Engineer and Superintendent Norfolk Water Co.

For Non-Resident Members.

William B. Fuller, Little Falls, N. J., Resident Engineer East Jersey Water Co.

William B. Brush, Brooklyn, N. Y., Civil Engineer.

For Associate.

The Thomas Hoey Supply and Manufacturing Co., Boston, Mill and Water Works Supplies.

On motion of Mr. Cassell, the Secretary was directed to cast one ballot in favor of the applicants, which he did, and they were declared elected members of the Association.

Mr. Charles W. Sherman, in behalf of the Boston Society of Civil Engineers, extended an invitation to the members of the Association to attend an informal meeting of the Boston Society, to be held in the evening, when Mr. F. E. Adams, of the Coffin Valve Co., would speak on "Essential Features of Gate Valve Construction."

Mr. George A. Stacy, Superintendent, Marlboro, Mass., then gave a description of the Marlboro Water Works, illustrating his remarks by stereopticon views.

Mr. Harry F. Gibbs, Engineer Water Works Pumping Station, Natick, Mass., read a paper entitled, "How to Obtain the Best Results in Small Pumping Stations." Mr. William F. Codd, Superintendent, Nantucket, Mass., followed with a short paper descriptive of a gasolene engine and its use as a reserve pumping plant in the Nantucket Works. Mr. D. N. Tower, Superintendent of the Cohasset Water Company, also spoke in regard to the Hornsby-Akroid kerosene oil engine in use at Cohasset.

Owing to the lateness of the hour, the further discussion of the report of the Committee on Standard Specifications for Cast-Iron Pipe was postponed to the next meeting.

Adjourned.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVI. June, 1902. No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

PRELIMINARY REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE, WITH DISCUSSION.

FREEMAN C. COFFIN,* F. F. FORBES,† AND DEXTER BRACKETT,‡ *Committee.*

[*Report presented December 11, 1901; the discussions printed herewith include all those received up to May 1, 1902.*]

MR. FREEMAN C. COFFIN. Before reading this report, I will say that we hope that the report, or at least the specifications accompanying it, will not be considered by you as in their final form. The Committee, although it has met some of the representatives of the manufacturing interests, and also some others who are particularly interested in this subject, has not been able, even yet, to consider the matter in connection with others, and to discuss the points as it would have liked to do, simply on account of lack of time and press of other business. The specifications as they are presented to you now embody the present ideas of the Committee, and are presented with the hope that there will be a thorough discussion of all the points, and that a final form of the specifications may be adopted in view of all the discussion and suggestions and criticisms which may be made; and your Committee also thinks it may be desirable for the Association to communicate with other bodies which are considering this subject at the present time. The Committee hopes that the specifications will be fully discussed and criticised, so that all the points may be brought up.

(Mr. Coffin then read the report of the Committee and the proposed specifications, as follows): —

BOSTON, November 22, 1901.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — In its consideration of this subject your Committee has assumed that it was your intention that its study should cover

* Civil Engineer, Boston, Mass. † Superintendent of Water Works, Brookline, Mass.
‡ Engineer Distribution Department, Metropolitan Water Works, Boston, Mass.

the design of cast-iron pipe and special castings, as well as the methods of their manufacture, and that its recommendations should include drawings of the pipes and special castings, tables of dimensions, and a list of weights for the different diameters and classes, in addition to specifications of the processes of manufacture and the character of the pipes when completed.

The Committee has conceived its duty to be not the recommendation of new processes, radical changes in existing specifications, nor even an unvarying list of weights for different heads or pressures, but rather a codification of the best present practice in design and manufacture in such form that, if used as a standard, pipe can be furnished by the manufacturers and procured by purchasers with more certainty of satisfaction than can be done at present, even with the most perfect individual specifications, and at the same time to be sufficiently elastic to allow, with a minimum of trouble, the incorporation of special ideas in an order for pipes.

It is believed that standard specifications to obtain general acceptance must allow for the personal equation of the user. While the many difficulties attending the present individualistic methods are well known, the Committee recognizes the futility of the adoption of a standard which, although securing uniformity, too closely limits individual freedom of practice.

The specifications recommended will not be wholly satisfactory to those who hope for an instrument which will of itself, without further thought or study, automatically regulate the whole business of securing suitable pipe for use under all conditions. The Committee believes, however, that it is practicable to arrange standards in such a manner that no one adopting them will be obliged to depart widely from his own practice, while at the same time many of the difficulties now attending the purchase and use of cast-iron pipes will be avoided.

SOME OF THE DIFFICULTIES OF PRESENT PRACTICE.

Form and Dimensions of Pipes and Castings. — The variation in form and dimensions of pipes and castings from different foundries, and even in different lots from the same foundry, causes much trouble and expense in pipe laying. Special castings are the most troublesome in this respect, spigots often being too large or thick to allow sufficient lead room in the bell of the pipe, even if they will enter at all without chipping the bead. Different classes of pipe

often cause trouble in the same way, especially when the different thickness of shell is secured by a change in the outside diameter.

Unless drawings are furnished for special castings (which it is not always practicable to do, especially for small orders), one does not know the length or weight, or even if the castings will come with bell and spigots, or bells all around. Sometimes reducers are sent with bells on the large end and sometimes on the small end. The radii of bends can rarely be ascertained in advance.

Even when drawings are furnished, unless an inspector is at the works, the castings are quite as likely to come of some other pattern and weight (not usually lighter), when the alternatives are to use those sent or wait for others to be cast and delivered.

On the other hand, it is clearly impossible for the manufacturer to keep a stock of pipe or specials on hand, when he cannot be sure that any two orders will have the same requirements, even in the simplest detail.

The entire lack of system in fixing the weights of pipes is the cause of much trouble and perplexity, the weight cards of the different foundries agreeing no better than the tables of different engineers. The great variety in specifications not only causes trouble in the foundry, but results to the purchaser of pipe not inspected at the works and of pipe in small lots or on quick orders, in the receipt of pipe which, although it may make fairly good work when laid, is nothing more nor less than a job lot of different sorts and sizes, very difficult to lay.

RECOMMENDATIONS.

In an endeavor to simplify and unify the practice in the manufacture and use of cast-iron pipes and special castings, your Committee makes the following suggestions, which are embodied in the appended *Standard Specifications for Cast-Iron Pipe*, which it recommends to the Association for adoption.

DESIGN.

Length.—The standard length of the pipes shall be 12 feet, exclusive of the bell or socket.

Diameters.—For sizes from 4 to 18 inches, inclusive, the inside diameter of pipes of a given nominal size shall be varied in accordance with the varying thickness used for different pressures or conditions, and the outside diameter for all classes or weights shall be

uniform. For sizes larger than 18 inches, there shall be three sizes for the outside diameter of each nominal diameter.

It is feared that if one outside diameter were adopted for all classes in the larger sizes of pipes, it would cause so much difficulty in connecting future pipe to that already laid, and in making repairs, that it would be a serious obstacle to the adoption of the standard. It is also believed that the use of more than one outside diameter will not cause so much trouble in the larger sizes as in the smaller ones.

The Committee has endeavored to suggest outside diameters for the several sizes of pipes that will conform as nearly as possible to sizes in general use at the present time, and, also, those which will give the full interior diameter for the thickest pipe in common use. The outside diameters proposed by the Committee are given in Table No. 1 of the specifications.

Depth and Joint Room of Bells. — There is undoubtedly considerable variation in present practice in the depth of bells. The Committee is of the opinion that good results are secured with all depths used, and that an exact depth of bell is not an essential matter to any engineer. Therefore, as the use of a standard bell will do much to simplify the casting of pipe, it recommends the adoption of the list of depths given in Table No. 1. These depths are believed to conform very nearly to the average practice.

Although the practice regarding variation in joint room is not as great as in the depth of the bells, the Committee was influenced by the same reasons to recommend a uniform list of thickness, which is also found in Table No. 1.

If Table No. 1 is adopted as the standard, and adhered to, the result will be that every pipe and special casting under 20 inches in diameter will fit every other pipe and casting of the same nominal size.

Thickness and Weight of Pipe. — In the classification of cast-iron pipe for different pressures and conditions is to be found a more serious divergence of opinion and practice than in any other branch of the subject. The Committee has not deemed it advisable to recommend the adoption of standard weights for stated pressures for the reason that the thickness or weight of the pipe to be used depends in many cases upon other conditions in addition to the static pressure. In pipes of the smaller sizes the thickness required depends upon the strength needed to withstand handling and the strains

due to the settlement of earth, and other causes, rather than upon the internal pressure. For this reason heavier pipes are required in city streets, where they are subjected to settlement from frequent excavations, than in country towns where they remain undisturbed.

Other conditions beside the pressure must also be considered in determining the thickness of the large sizes of pipe; for example, large pipes in public streets, where they may be subject to heavy loads, or in places where the depth of earth covering is great, should be made thicker than where laid in locations specially reserved for their use. The static head or pressure can be closely estimated, but the water hammer, effect of traffic over the pipe, settlement under it, tuberculation within it, electrolysis outside of it, and age everywhere, can, with present knowledge, be given no mathematical value. These conditions must, however, be taken into consideration in determining the thickness of pipe to be used in any given case.

It is probable that no formula exists which is a scientific expression of all these requirements — perhaps no such rational formula can be devised, certainly not until more definite data are secured for the various strains, both internal and external, which are sustained by pipes in use. It was finally decided to devise a table of thicknesses and weights based upon some logical formula, and to give the different weights an arbitrary classification denoted by a symbol such as a letter of the alphabet, in which the variation in weights from one class to another should not be so great that one would be unable to select pipes that would approximate his own practice and of sufficient range to cover all except the most extreme cases.

The thicknesses given in Table No. 2 were computed by the following formula, which is one used in determining the thickness of pipe used on the Metropolitan Water Works, which supply water to Boston and other cities and towns within a radius of ten miles; Class A being for a static head of fifty feet, Class B for one hundred feet, etc., each class advancing by fifty feet. This formula provides factors for the deterioration of the pipe by time and other conditions, for the internal strain due to the static head and to water hammer, but, as has been previously stated, other conditions must also be considered.

$$t = \frac{(p + p')r}{3300} + 0.25 \text{ in which}$$

t = thickness in inches;

p = static pressure in pounds per square inch;

p' = pressure in pounds allowed for water hammer;
r = internal radius of pipe in inches;
3 300 = 1/5 tensile strength of cast iron taken to be 16 500 pounds per square inch;
0.25 = allowance for deterioration by corrosion and other causes.

VALUES GIVEN TO P' AS FOLLOWS:

Diameter of Pipe.	*P' in Pounds.*
4, 6, 8, and 10 inch.	120
12 and 14 inch.	110
16 and 18 inch.	100
20 inch.	90
24 inch.	85
30 inch.	80
36 inch.	75
42 to 60 inch.	70

The Committee does not recommend the classification of the weights upon the basis of static head, believing that to the engineer or superintendent should be left the final decision as to the thickness or weight of pipe suitable for the particular place in which it is to be used.

Table No. 2, if adopted, will furnish a basis for pipe practice in which the classes will have a uniform meaning, and when used as the basis of an order will insure to the buyer the pipe which he intends to use. This will be a distinct improvement on present conditions under which a class letter has no meaning, except when accompanied by a statement of weight.

The table does not assume to fix the weight which shall be used for different heads or conditions of service. It is believed that the range is sufficient to provide for all usual conditions, and that the variation between one class and the next is not great enough to prevent the selection of weights that will closely approximate individual practice.

This uniform classification does not necessitate any radical departure from present foundry methods, yet it can hardly fail to be of advantage to the pipe manufacturer, especially in providing standard weights for stock pipe.

Special Castings. — In general design, the special castings recommended are of the pattern now used on the Metropolitan Water Works. A number of foundries have the patterns for these castings, and they are already in a fair way to become a standard.

The Committee is of the opinion that it would be difficult to improve upon these patterns. They are designed with the purpose of

putting as little metal into the special castings (where it costs about twice as much as it does in straight pipe) as is consistent with strength and convenience in laying.

As the specifications allow a margin for excess or deficiency in weight of not exceeding six per cent., abnormal excess of weight (a serious fault in many castings) is avoided, and the purchaser can estimate with reasonable accuracy the cost of the castings in advance.

The outside diameter and the openings of the bell or socket are the same as those of the pipes of the same size. There is but one class of special castings for all classes of pipe below twenty inches. It is hoped that the vexing occurrence of the necessity for chipping spigots of special castings to enable them to enter the pipe bells, which has heretofore been much too common, will be avoided by this uniformity.

Tables giving full dimensions and weights will accompany the specifications in their final form.

Manufacture.—The clauses of the specifications which refer to the processes of the manufacture of the pipe and castings are recommended by the Committee as representing in its opinion the best modern practice which has been tested by time and experience.

There are some points which are as yet unsettled, such, for instance, as the coating of the pipes. The Committee believes that the method specified is the most satisfactory one in general use. It recognizes, however, that improvement in this matter is to be desired. It is possible that some of the processes already suggested may prove to be better. They are yet in the experimental stage, and, therefore, not suitable subjects for recommendation. Even standard specifications must be subject to revision, as experience shows their requirements to be rendered obsolete by better methods. It is, of course, always open to the purchaser to substitute requirements of his own for any clause or clauses of the specifications or in addition thereto. The fact that he may often choose to do so does not impair the value of standard specifications.

In conclusion, the Committee will state that the specifications are recommended to the Association for criticism and amendment, if thorough discussion by all interested shows changes to be desirable.

Respectfully submitted,

FREEMAN C. COFFIN,
F. F. FORBES,
DEXTER BRACKETT,

Committee on Standard Specifications for Cast-Iron Pipe.

SPECIFICATIONS.

DESCRIPTION OF PIPES.

The pipes shall be made with hub and spigot joints, which shall accurately conform to the dimensions given in Table No. 1.

They shall be true circles in sections, with their inner and outer surfaces concentric.

The straight pipes shall be straight, and the curved pipes shall be true to the required curvature in the direction of their axes.

They shall be of the specified dimensions in internal diameter from end to end, and the straight pipe shall be twelve feet in length, exclusive of socket.

Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint-room from any cause. The joint-room for each class of pipe shall not vary more than .06 of an inch from the dimensions given in Table No. 1.

No pipe shall be accepted when the thickness of metal in the body of the pipe is more than .08 of an inch less at any point than the standard thickness given in Table No. 2.

The length of the pipe shall not be changed except by written permission of the engineer, and in case of such change the standard weight of the pipe given in Table No. 2 shall be modified in accordance therewith.

DEFECTIVE SPIGOTS.

Defective spigot ends on pipes twenty inches or more in diameter may be cut off in a lathe, and a half round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than six per cent. of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than eleven feet in length, exclusive of the socket.

SPECIAL CASTINGS.

All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The contractor shall furnish and deliver all bolts for

bolting on the manhole covers, the bolts to be of the sizes shown on plans; and made of the best quality of American refined iron, with hexagonal heads and nuts, and sound, well-fitting threads.

MARKING.

Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name, the year in which it was cast, and the class letter. When cast especially to order, each pipe and special casting shall also have cast upon it the number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below; thus: —

1901,	1901,	1901,
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser.

The letters and figures to be cast on the outside, not less than two inches in length and one eighth of an inch in relief.

PERCENTAGE TO BE PAID FOR.

No pipe shall be accepted the weight of which shall be less than the standard weight by more than four per cent. for pipes 16 inches or less in diameter, three and one-half per cent. for 18-, 20-, and 24-inch pipes, and three per cent. for pipes more than 24 inches in diameter; and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe the sum of the standard weights for the same number of pieces of the given size and class by more than two per cent.

No special castings shall be accepted the weight of which is more than six per cent. less than the standard weight, and not more than six per cent. in excess of the standard weight shall be paid for.

QUALITY OF IRON.

The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace. It shall be of such character as to make a pipe strong, tough, and of even grain, and soft enough to satisfactorily admit of drilling and cutting.

Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 2 000 pounds, and show a deflection of not less than .35 of an inch before breaking. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

HOW CAST.

The straight pipes shall be cast in dry sand molds, in a vertical position, with the hub-end down, and the special castings in loam, except when otherwise permitted in writing, in either case, by the engineer.

The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

QUALITY OF CASTINGS.

The pipes and castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature. No plugging or filling will be allowed.

CLEANING AND INSPECTION.

All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped. The contractor shall provide a covered tramway from the casting-room to the dipping vat, so that no casting shall be liable to become wet previous to its being coated.

COATING.

Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit immediately before it is dipped, and shall possess not

less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahrenheit (or less, if the engineer shall so order) and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

HYDROSTATIC TEST.

When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows: —

Class	A	pipe,	150	pounds	per	square	inch.
„	B	„	200	„	„	„	„
„	C	„	250	„	„	„	„
„	D	„	300	„	„	„	„
„	E	„	350	„	„	„	„
„	F	„	400	„	„	„	„

They shall also be subjected to the same proof by water pressure and hammer test after their delivery and before their final acceptance, if required by the engineer.

WEIGHING.

The pipes and special castings shall be weighed for payment under the supervision of the engineer, after the application of the coal-tar pitch varnish, and the weight of each pipe and special casting shall be conspicuously painted in white on the inside, after the coating has become hard. If desired by the engineer, the pipes and special cast-

ings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement.

CONTRACTOR TO FURNISH MEN AND MATERIALS.

The contractor shall provide all tools, materials, and men necessary for the proper testing, inspection, and weighing at the foundry of the pipes and special castings; and if required by the engineer, he shall furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the transverse tests upon the test bars.

POWER OF THE ENGINEER TO INSPECT.

The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which in his opinion is not in conformity with the specifications or drawings furnished. He shall have the power to prevent the use of any metal, mold, or core which in his opinion may not be proper for the purpose for which it is intended.

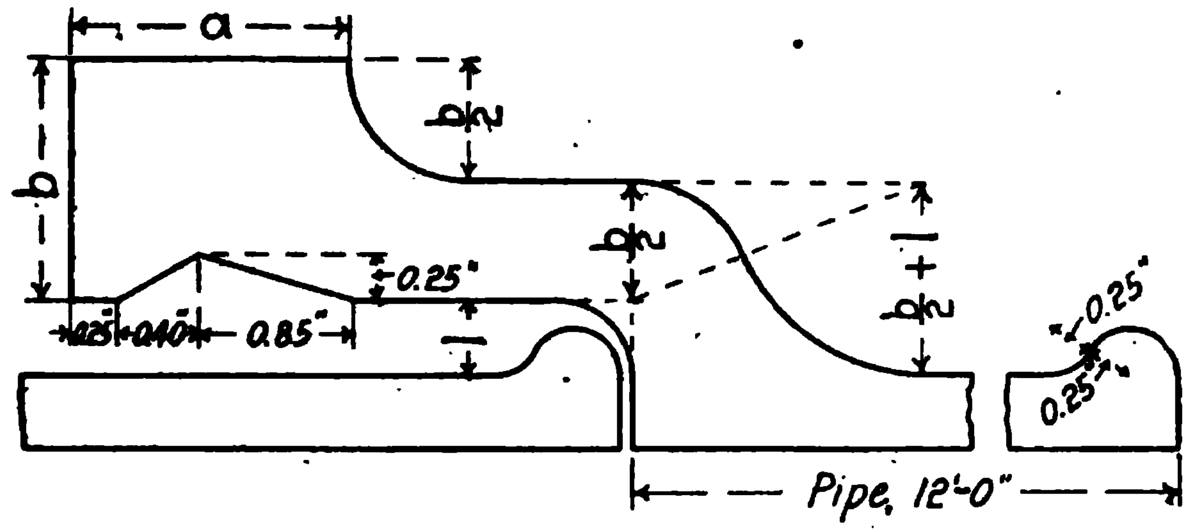
CASTINGS TO BE DELIVERED SOUND AND PERFECT.

All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other casting which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

DEFINITION OF THE WORD "ENGINEER."

Wherever the word "engineer" is used herein it shall be understood to refer to the engineer, or inspector, acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.

Table No. 1
General Dimensions of Pipes and Special Castings.



Nominal Diam. Inches	Class	Actual Outside Diam. Inches	Depth of Sockets: Pipe. Inches	Depth of Sockets: Special Castings. Inches	Thickness of joint for calking—Inches	"a"	"b"
4	All Classes	4.90	3.00	4.00	.40	1.50	1.30
6	" "	7.00	"	"	"	"	1.40
8	" "	9.10	3.50	"	"	"	1.50
10	" "	11.30	"	4.50	"	"	1.50
12	" "	13.40	"	"	"	"	1.60
14	" "	15.50	"	"	"	"	1.70
16	" "	17.60	4.00	5.00	.50	1.75	1.80
18	" "	19.70	"	"	"	"	1.90
20	Classes A&B	21.30	"	"	"	"	2.00
"	" C-D	21.60	"	"	"	"	"
"	" E-F	21.80	"	"	"	"	"
24	" A-B	25.40	"	"	"	2.00	2.10
"	" C-D	25.80	"	"	"	"	"
"	" E-F	26.10	"	"	"	"	"
30	" A-B	31.60	4.50	"	"	"	2.30
"	" C-D	32.00	"	"	"	"	"
"	" E-F	32.40	"	"	"	"	"
36	" A-B	37.80	"	"	"	"	2.50
"	" C-D	38.30	"	"	"	"	"
"	" E-F	38.70	"	"	"	"	"
42	" A-B	44.00	5.00	"	"	"	2.80
"	" C-D	44.50	"	"	"	"	"
"	" E-F	45.10	"	"	"	"	"
48	" A-B	50.20	"	"	"	"	3.00
"	" C-D	50.80	"	"	"	"	"
"	" E-F	51.40	"	"	"	"	"
54	" A-B	56.40	5.50	5.50	"	2.25	3.20
"	" C-D	57.10	"	"	"	"	"
"	" E-F	57.80	"	"	"	"	3.80
60	" A-B	62.60	"	"	"	"	3.40
"	" C-D	63.40	"	"	"	"	"
"	" E-F	64.20	"	"	"	"	4.00

Table No. 2

Standard Thickness and Weight of Cast Iron Pipe.

12 feet in length exclusive of socket.

Nominal Diameter of Pipe Inches	Class A		Class B		Class C		Class D	
	Thickness of shell Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length
4	.34	200	.35	207	.36	212	.38	218
6	38	330	.40	340	.42	355	.44	370
8	.42	475	.45	500	.48	525	.50	550
10	.47	650	.50	685	.53	725	.56	765
12	.49	810	.53	865	.57	920	.61	980
14	.53	1010	.57	1085	.61	1155	.66	1230
16	.55	1215	.60	1310	.65	1410	.70	1500
18	.57	1410	.63	1540	.69	1660	.75	1790
20	.60	1610	.66	1760	.72	1920	.79	2080
24	.64	2050	.72	2290	.80	2530	.88	2770
30	.71	2860	.81	3230	.91	3600	1.01	3950
36	.79	3800	.90	4270	1.02	4830	1.13	5300
42	.87	4900	1.00	5560	1.13	6270	1.27	6970
48	.95	6130	1.10	6970	1.25	7900	1.40	8780
54	1.03	7510	1.20	8600	1.37	9800	1.54	10900
60	1.10	8900	1.30	10300	1.50	11900	1.70	13300

Nominal Diameter of Pipe. Inches	Class E		Class F		Class G	
	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length
4	.39	225	.40	230	.42	240
6	.46	385	.48	400	.50	415
8	.53	575	.56	600	.58	630
10	.60	805	.63	845	.67	885
12	.65	1035	.69	1090	.73	1150
14	.70	1300	.75	1380	.79	1450
16	.75	1600	.80	1700		
18	.80	1910	.86	2040		
20	.85	2250	.92	2410		
24	.95	3000	1.03	3240		
30	1.10	4320	1.20	4680		
36	1.25	5900	1.37	6360		
42	1.40	7700	1.53	8350		
48	1.55	9740	1.70	10600		
54	1.72	12350	1.90	13500		
60	1.90	15100	2.10	16500		

DISCUSSION.

Mr. Coffin. As it is desirable to have a full discussion here by all who are interested, and as all who have received the advance copy of the report have been invited to discuss it either by letter or orally; and as there is, I believe, a clause in the by-laws or constitution which requires some action of the Association in relation to discussion by others than members, it may be in order for me to make a motion that this discussion be open to all who are interested in the subject.

Adopted.

The Chairman. The matter is now open for discussion. I think we would like to hear from the other members of the Committee, and I will call upon Mr. Brackett.

Mr. Dexter Brackett. It seems to me, Mr. Chairman, that the Committee having presented its report, the members should now discuss the subject, and if any questions arise I shall be very glad to explain my position on the subject. The report of the Committee contains my ideas, subject to revision, as suggestions may be made by the members.

Mr. Emil L. Nuebling* (by letter). The Committee on Standard Specifications for Cast-Iron Pipe has made a move in the right direction by recommending that the outside diameters shall be made uniform for all classes of pipes under twenty inches in diameter, and would not have been severely censured if this practice had been extended to include all sizes of pipes. Standard sizes, to be perfect, should not be burdened with several subdivisions, and so long as there are several standard sizes of pipe for one nominal diameter, the general adoption of the standard specifications will not take place. The benefits to be derived by the adoption of a single standard greatly outweigh the objections to it. If the standard outside diameter is proportioned by the formula given by the Committee (making p equal 120 pounds per square inch) it will conform to the bulk of the pipes in use at the present time. The objection made by the committee, that it would cause much difficulty in connecting future pipes to those already laid, can be readily overcome by the use of a casting of short length, having a standard spigot on one end and a bell or hub on the other end large enough to go over the old style of pipe. The benefits of a single standard are many, to manufacturers as well

* Engineer and Superintendent of Water Works, Reading, Pa.

as users. If a standard were in universal use, the manufacturers of pipe would be saved the expense of providing many different sizes of pipe patterns, and this might eventually result in the general introduction of the rotary mold ramming machine, which will give better workmanship at less cost. Manufacturers of gates, fire hydrants, and special castings will be equally benefited with the pipe manufacturers by using a single pattern for all bells and hub ends. The single standard will also save carrying a miscellaneous lot of gates and specials on hand, having different sizes of bell openings, in localities where all the different classes of pipes would be in use. A special or gate made for a 48-inch Class E pipe would not be used on a Class B pipe, because the lead joint would be 1.1 inches thick, which is entirely too large for good work; so, to be prepared for any emergency, several specials or gates of each nominal diameter above eighteen inches would have to be kept in stock if the multiple standard is used.

The standard thickness of joints for calking should be made as small as possible, having no greater thickness of lead than is absolutely necessary for proper pouring and calking of joints. The strength of lead joints varies directly as their thickness. A joint $\frac{1}{4}$ inch in thickness is as strong again as a joint $\frac{1}{2}$ inch in thickness, because the larger joint has so much more area exposed to the pressure of the water back of it. We have laid several thousand feet of 36-inch pipe with lead joints $\frac{3}{8}$ inch in thickness, and have had no leaks on this line since it was laid, several years ago; while a line of 24-inch and 30-inch pipes with joints of from $\frac{5}{8}$ to $\frac{3}{4}$ inch in thickness is giving us very much trouble from leaks caused by the lead joints pushing out. With the merit of small joints in mind, the following suggestion is made: That the thickness of joints for calking be made $\frac{5}{16}$ inch for all sizes of pipes from 4 inches to 20 inches inclusive, $\frac{3}{8}$ inch for sizes from 24 inches to 42 inches inclusive, and $\frac{7}{16}$ inch for sizes from 48 inches to 60 inches inclusive.

Mr. Frank A. McInnes* (by letter). I have read with pleasure the able report of the Committee on Standard Specifications; its adoption would prove a long step in the right direction, to the advantage of consumer and manufacturer alike. The requirement of a uniform outside diameter is a wise innovation in general practice; it was adopted by the Boston Water Department three years ago, and since that time there has been a gratifying absence of the necessity

* Assistant Engineer, Engineering Department, City of Boston.

of chipping beads, and abnormally large or small joints have disappeared. One criticism, perhaps a somewhat selfish one, suggests itself, viz., in regard to the depths of bell; those proposed are, in my opinion, too shallow for pipe which is to be laid in the streets of a city where the danger of disturbance and settlement is ever present: our streets are so filled with pipes, conduits, tubes, etc., of all kinds, that we are forced to depend upon "open joints" in addition to "specials," to solve some of our problems.

There are two possible additions to the specifications which I would like to suggest, for discussion at least. The first is the insertion of a clause regarding chemical analysis: this is a feature in specifications for steel and wrought iron — why not apply it to cast iron? My attention was particularly called to this point by a succession of breaks in a 48-inch line (laid in 1869) which could not be satisfactorily explained; a chemical analysis, made in the case of each break, conclusively stamped the iron as "bad." It is conceivable that test bars might not have condemned this iron, as they are not infallible, particularly when their pouring and cooling are not closely watched; the pressure test, too, might easily fail in the case of brittle iron. A requirement stipulating the composition of the metal would be getting at the very foundation; it, of course, would not take the place of the test bar, but it might be employed occasionally to great advantage, at any time before the final payment. The very fact of the existence of such a clause in the specifications would be useful.

The second suggestion is the desirability of requiring that certain castings, such as $\frac{1}{8}$ and $\frac{1}{16}$ bends, branches, reducers, hydrants, etc., be made with green-sand cores. The principal advantage in this method of casting is in the fact that chaplets are not used; the arbor around which the core is formed passes out through the flask, and is held rigidly in place without further assistance. I think it will be granted that the chaplet is apt to be the weakest spot in a casting — a collection of them made during the past summer from our junk pile would convince the doubter of this fact. Another advantage of the green-sand method is that it is easier to get smooth, uniform castings in this way than with dry-sand cores. The method is applicable to castings up to twenty inches in diameter at least. For the past year, the bends (except quarter turns), the branches, reducers, sleeves, etc., (under 24-inch), and the hydrants used by the Boston Water Department have been made in green sand with marked success.

There is a further inviting field for investigation, namely, the

actual structure of the iron as disclosed by the microscope and by photography. Before long we will have to consider this feature in our specifications.

Mr. Louis H. Knapp* (by letter). I approve of Tables No. 1 and 2 in every respect, and think it very desirable to have them adopted.

The following clauses from the Buffalo specifications may be of interest: —

4. All pipes shall be cast vertically, and shall be made in such molding sand or loam as will leave the surface in good condition to receive the coal-tar varnish.

5. The metal of which the pipes are made shall be iron, remelted in a cupola or air furnace, and of such make as shall be approved by the engineer.

It shall be without any admixture of cinder iron or inferior metal, entirely free from uncombined carbon, when seen under the microscope, and shall admit of being easily drilled or cut. The iron in the pipe shall have a tensile strength of at least eighteen thousand (18 000) pounds to the square inch.

I think some reference should be made to the quality of the sand; also, the tensile strength of the cast iron should be specified.

I would leave out the clause relating to defective spigots in the general specifications, and leave the question of defective ends to the engineer or inspector.

13. Every pipe shall be carefully coated inside and out with coal-tar pitch and oil, in accordance with the following rules: —

Every pipe must be thoroughly dressed and made clean, free from the earth or sand which clings to the iron in the mold.

Every pipe must be entirely free from rust and dust when the coating is applied. If the pipe cannot be dipped immediately after being cleaned, the surface must be oiled with linseed oil to preserve it until it is ready to be dipped; no pipe to be dipped after the rust has set in.

The coal-tar pitch is to be made from coal tar, distilled until the naphtha is entirely removed and the material deodorized. It should be distilled until it has about the consistency of wax when cold. The mixture of five or six per cent. of linseed oil is recommended. Pitch which becomes hard and brittle when cold will not answer.

Pitch of the proper quality, having been prepared, must be carefully heated in a suitable vessel to a temperature of 300 degrees Fahrenheit, and be maintained at not less than this temperature during the time of dipping. The material will thicken and deteriorate after a number of pipes have been dipped; fresh pitch must, therefore, be added from time to time, and occasionally the vessel must be entirely emptied of its contents and refilled with fresh pitch; the refuse will be hard and brittle, like common pitch.

Every pipe must attain a temperature of 300 degrees Fahrenheit before it is removed from the bath. It may then be removed and laid upon skids to drip.

Pipes of twenty inches diameter and upwards will require to remain at least thirty minutes in the hot fluid to attain this temperature, probably more in cold weather.

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* Engineer, Buffalo Water Works.

The application must be made to the satisfaction of the engineer, and the material and process be subject at all times to his examination, inspection, and approval.

I would not require the castings to be heated to 300 degrees before dipping, but would require them to obtain that temperature in the vat.

The hydrostatic test should be as you have it, and not for a general pressure of three hundred pounds for all pipes.

In general the specifications as you have reported are a great improvement and advance over what has been used in the past. As a whole I am in favor of them.

R. D. Wood & Co.* (by letter). With your esteemed favor of December 4 to Mr. Walter Wood, we received the copies of report of Committee of the New England Water Works Association on Standard Specifications, showing the suggested form for such specifications. We at once referred it to our foundrymen, and communicated with other pipe foundries. As yet we are unable to get satisfactory or complete reports as to how much the various changes would affect the expense and trouble of making pipe and specials. This extra cost would eventually, of course, be borne by the buyers, and would be a disadvantage to all foundries. There are some details which, for the mutual interests of water works and pipe makers, should be modified,—to what extent we cannot state until we can get an agreement with other foundries as to what would be a fair average of the several interests. Unfortunately, in the short time we have had the pamphlet, this has not been practicable, and we trust that no final action may be taken until we can meet your Committee with a full statement of our ideas on the several changes.

The Chairman. We have a representative of the United States Pipe Foundry here, Mr. Lemoine, and we would like to hear from him.

Mr. L. R. Lemoine. I do not know that there is very much that I can say on behalf of the manufacturers, because, as has been intimated in the letter just read, we have not had an opportunity of getting together. I can say on behalf of our own company, however, that a glance at these specifications indicates that there are a number of points in them which, from a manufacturer's standpoint, we think it would be to the interest of your Association to have carefully considered before they are incorporated in the final report. I have

*Pipe Founders, Philadelphia, Pa.

spoken to Mr. Brackett in regard to the matter to-day, and I will venture to refer to just one item. It is stated in one clause here that special castings must all be made in loam. That matter has been mentioned in one of the papers which has been read, — I think it was in Mr. McInnes'. Now, the general practice at most foundries, I think I am safe in saying, is that upwards of three fourths, if not four fifths of the special castings are made in green sand; and as the specials grow larger the practice in making them varies from green sand to a combination of dry sand and loam, and then loam. The practice also varies with the number of specials of a particular kind. For instance, take a 48-inch, $\frac{1}{16}$ bend; if only one is required for a certain dimension it may be cheaper to sweep it up. On the other hand, if there are fifty or sixty of them, it may be cheaper to make them in a combination of dry sand and loam, or entirely in dry sand, depending somewhat on the radius of the bend.

There are a great many items in the proposed specifications which I am sure the Committee will permit us at least to point out to them, which make it seem best, if the Association agrees with us, to have this matter referred back to the Committee, and ask them at their convenience to confer with the manufacturers — after giving the manufacturers a chance to confer among themselves; for I presume the Committee would like to have the manufacturers fully agreed before meeting them.

The Chairman. Before we have a discussion by any users of pipe, if there are any other representatives of pipe foundries here, we would like to hear from them.

Mr. Edmund F. Krewson. Mr. President and gentlemen, I represent R. D. Wood & Co. Mr. Lemoine has expressed our position quite fully. We are in hearty sympathy with this movement, and we realize the intelligence and care with which these specifications have been prepared; and yet we are unprepared to accept them until these matters, some of which Mr. Lemoine has indicated, are more thoroughly threshed out among the foundrymen. We have tried to get together, but we have been delayed. We think, however, in a short time we will be able to make such a presentation to your Committee as will be mutually satisfactory. We have no items to suggest now, being comparatively unprepared. I can therefore simply endorse Mr. Lemoine's position and say that we would like an extension of time.

Mr. Coffin. I believe Mr. Edwards, who represents the Montreal

Pipe and Foundry Company of Canada, is here, and I should like to hear from him.

MR. EDWARDS. I regret to say, Mr. President, that I have not the honor to be a member of the Association, but I have come here in response to the general invitation which is extended with the advance copy of the Committee's report. I might say that our views would be very much in line with those which have been expressed by previous speakers representing the manufacturers, namely, that there are many points here which ought to be handled with considerable care, and awaiting, possibly, the decision of the manufacturers.

If you will permit me, I will run over some of the matters mentioned in this printed draft of the report. In the first place, I would say, that the company which I represent probably differs from the larger companies in the United States, in that we make chiefly small pipe. We make mostly 6-inch, 8-inch, 10-inch, and 12-inch. While we have facilities for making the larger pipe, still 24-inch is the maximum size that we usually make. What I shall say, therefore, will have reference chiefly to small pipe.

The questions of joint room, and such matters, are ordinarily in the hands of the engineers, and they do not matter very much to the manufacturer, so far as I judge.

In connection with the percentage of accepted pipes which have cut ends, I notice it says that "no pipe shall be banded which is less than eleven feet in length, exclusive of the socket," and "not more than six per cent. of the total number of accepted pipes of each size shall be cut and banded." I presume that refers to pipes twenty inches or more in diameter, but by inference it would cover all classes of pipe. I should think, from the manufacturers' standpoint, that ten per cent. of cut ends would be a fair allowance, because fully that number are turned out from the average factory, and if only six per cent. were accepted it would throw a considerable percentage upon the manufacturers. I know the custom with us has been to include ten per cent., and in most cases that has been acceptable.

Then, as regards marking. The class letter is a point that is rather hard on the manufacturers, because in casting it is impossible to get the weights of pipe within the limits of the class provided in these specifications; and if a pipe were branded with a certain class letter, in case the weight limit was not reached or was exceeded, it would be branded in the wrong class, and would be rather bad stock

in the hands of the manufacturer. He would have to chip the class letter off and paint on a new one, which would rather detract from the value of the pipe. It seemed to me that the class letter could be very well left out, in the interest of the manufacturers.

And, also, the number signifying the order in point of time in which the pipe is cast is a point. While it is undoubtedly valuable to the engineer to know the running number of his pipes, still the pipe might be thrown back on the hands of the manufacturer through the clause which usually permits the engineer to decrease the contract by, say, twenty per cent.; and a pipe which was thrown back upon the hands of the manufacturer, bearing a certain number cast on it and also a class letter, would be dead stock, or stock for which there would certainly be but a limited demand.

Then, again, in small pipe, — and I am referring to small pipe especially, — the question of casting with hub end or bell end down, judging from the literature that is to be had in regard to the casting of pipes, is a matter on which there is a wide divergence of opinion at present; but these specifications would call for all pipes, no matter how small, to be cast with the bell end down. I know that the three factories which I represent have a large plant for casting with the bell end up, and to make a change would necessitate the incurring of considerable expense.

Special castings to be cast in loam is another feature, which a previous speaker has touched on. I know in our case green sand is used almost entirely for small castings.

On the question of hydrostatic test, it is provided in the specifications that all pipes in Classes E and F are to have, respectively, a pressure of 350 and 400 pounds per square inch. Now, applying that to the smaller sizes of pipes, the 4-inch and 6-inch, and even 8-inch pipe, even with the thickness provided for these respective classes, it is a very heavy pressure on pipe for purposes of testing in the foundry; and it seemed to me that a change to the effect that pipes, say under twenty inches, need not be tested to a higher figure than 300 pounds would cover the ground very well. According to this, a 4-inch pipe in Class G only runs twenty pounds to the foot, which is a fair average weight from previous practice, and that would be subject to a test of 400 pounds to the square inch.

That brings up the question of the weights of pipe as provided here, Class A, 4-inch, being down as low as 200 pounds, and the very heaviest class only being 240 pounds. I think the experience of pipe

manufacturers has been that those figures have been very radically exceeded in average work, running from 230 as a minimum, perhaps, to 260 or 270 as a maximum, instead of from 200 to 240.

I just mention these points, Mr. President, as briefly indicating our views on the matter.

THE CHAIRMAN. It has always seemed to me that if there was any difference in the quality of the iron the best iron should be in the bell end rather than to have it in the spigot end.

MR. DEXTER BRACKETT. In explanation of some remarks made by Mr. Edwards, I wish to state, with regard to defective spigots, that this clause in the specifications is intended to provide that the spigot ends on pipes smaller than twenty inches shall not be cut off under any condition. This rule I have followed in my practice, and I think it has been followed by many other engineers, and I might say that the foundrymen do not seem to have any difficulty in making pipes of which a very small percentage are rejected for that cause. The reason for allowing a small percentage of the larger sizes to be cut and banded is that the loss of a large pipe is of more importance than of the smaller sizes.

In regard to the casting of the special castings in loam, I must say that the insertion of that clause in its present form was a mistake, as I knew that special castings, of the smaller sizes, are not made in loam, and although the specifications state that they may be made in other ways by special permission, it would hardly be desirable to require special permission for every order for small castings.

With regard to the suggestion that the hydrostatic test required is excessive for smaller sizes of pipe, I would say that if any criticism were to be made it should be made in directly the opposite direction. For the smaller sizes of pipe, the formula used provides an addition of .25 of an inch in thickness for deterioration by corrosion. For this reason, the thickness of the smaller sizes is double that needed to withstand the pressure for which the pipes are designed, while for pipes of large diameter the addition of .25 of an inch is a much smaller proportion of the total thickness, and there is more risk of getting an excessive pressure in testing the large sizes than there is in testing the small ones. I think that any of the smaller sizes of pipe will probably withstand, when new, a pressure of one thousand pounds per square inch.

MR. W. H. RICHARDS.* It is with much hesitation that I offer any

* Superintendent of Water Works, New London, Conn.

criticism of the specifications for cast-iron pipe as presented by the Committee, knowing the difficulties under which the Committee labors in an endeavor to reconcile the many divergent ideas on the subject; but as suggestions are invited, I offer the following: —

(1) That the specification contain a specific declaration that no cut pipe under twenty inches in diameter will be accepted.

(2) That the hydrostatic testing pressure be reduced as the size of pipe increases, thus giving a more nearly uniform strain on the iron. As specified, the actual strain on a 24-inch Class D pipe is double that on a 6-inch Class D pipe, which is inconsistent.

(3) That further consideration be given by the Committee to the depth of bells. Examples are not wanting in nearby cities of bells on 10-inch and 12-inch pipe less than three inches deep, and after years of use. As the saving in weight of one inch depth on the bell is nearly equivalent to all the saving between two classes of pipe, there ought to be a good reason given for adhering to an antiquated design.

Mr. Brackett. The thickness in the small pipes is not required to withstand the internal pressure, but the strain due to settlement. In fact, I think in Boston they now use fully as heavy pipes for gas as they do for water.

Mr. Robert J. Thomas. I would like to hear from Mr. Macksey, of the Boston Water Works.

Mr. H. V. Macksey. I have very little to add to the discussion at this time. Mr. Edwards seemed to think that the branding of the classification would cause some difficulty for the manufacturers. I cannot see that any great expense would be caused thereby. My experience has been that manufacturers have always kept very well within the weights specified, the pipe running too heavy rather than too light as a rule; but if a manufacturer feared that he could not keep within his limits and would have a wrong letter branded on a pipe, I see no reason why he could n't brand all the letters in series on a pipe and then take the one which fits the pipe as cast. For instance, he could have three class brands and then cut off the two which do not fit. There would be very little labor lost. So, also, in regard to putting on any special water-works brand which may be desired, and the numbering of the pipe. It seems to me very important that there should be a method of identifying pipe, because experience has shown that quite a number of pipes which have been condemned at the factories reach the works. It is a very

easy matter for the manufacturer to cut off any brand, provided the pipe is rejected at the foundry. It has been my practice to request that that be done immediately, and the manufacturers have always complied, with the exception of one who made it a practice to break up all small pipe which were refused by inspectors, never putting any into stock. So really I cannot see that these little things would make any practical difference to the manufacturers, and I think they are very important to water departments. I quite agree with the Chairman that the place to have good iron is in the socket, and I think that the specification as to the position in which the pipes should be cast is quite important.

THE CHAIRMAN. I will call upon Mr. Gould, engineer of the Gas Companies.

MR. J. A. GOULD.* I do not know that I have anything of importance to add, only, as the subject of gas pipes has been mentioned, I will say that the gas pipes used in the city of Boston are as heavy as the high-service pipes which are used by the Boston Water Department. A 12-foot length of 8-inch gas pipe weighs six hundred pounds, the same as pipes used for the high-pressure service, while the gas pressure is about two ounces to the square inch.

THE CHAIRMAN. Do you have any breaks?

MR. GOULD. We do.

I do not think I have any real criticism to make upon the report of this Committee, but will mention one thought that has occurred to me; that is, whether it is necessary to have so many different classes of pipe, varying for each fifty feet of head, or for each twenty-two pounds of pressure.

A pipe that is thick enough to take a good thread for the service tap is strong enough to stand the water pressure of most water works. For instance, a 6-inch pipe that is three-eighths inches in thickness can be tapped satisfactorily for water or gas services; and this is practically the thickness of a light-weight gas pipe. This pipe, if made of iron of the standard tensile strength of sixteen thousand pounds to the square inch, should not break until it is subjected to a water pressure of two thousand pounds to the square inch.

The danger to most pipes is not from the pressure in the pipes, but from the strains due to the settlement of the material in which

* Chief Engineer, Brookline and Dorchester Gas Light Companies.

the pipe is laid. For this reason it has been the custom of the local gas companies to order two classes of pipes; one which corresponds closely to the Class B of this report, or suitable for one hundred feet of water, is laid in the suburban districts, and another class, which has practically the same weight as the high-service pipe of the Boston Water Department, is laid in city streets where the pipe is liable to be undermined by other parties, especially the Sewer Department.

In this connection a list of the weights of gas mains laid in Boston and vicinity may be of interest.

Diameter, Inches.	*Suburban weights, Pounds per 12-ft. length.*	*City weights, Pounds per 12-ft. length.*
4	230	260
6	350	400
8	500	600
10	675	800
12	850	1 000
16	1 300	1 485
20	1 850	2 100
24	2 400	2 700
30	3 600	4 000
36	5 200	5 200
42	6 200	6 200

By comparison with the tables of weights in report of the Committee, I think few water-works engineers would hesitate to trust the pressure from their works in pipes of above weights, while the gas engineers with no internal pressure in their pipes demand these heavy pipes for other reasons.

MR. FRANK L. FULLER.* I think this Committee has done a good thing in recommending a scheme by which foundries can make pipe to keep in stock. We all know how troublesome it sometimes is, when we are in a hurry to get an order of pipe, to have to wait for it to be cast, because we cannot get just what we want. Now it seems to me that this will obviate that trouble to a large extent, and I think there will be less pipe laid which is unnecessarily heavy. I remember that the first pipe which was laid in the town of Marblehead was a 10-inch line, bringing water from a little pond to supply several hydrants. I do not suppose the head was more

* Civil Engineer, Boston, Mass.

than fifty feet, but that 10-inch pipe weighed eighty pounds to the foot, which, of course, was vastly heavier than there was any necessity for.

On page 92 it is specified that "No pipe shall be accepted when the thickness of metal in the body of the pipe is more than .08 of an inch less at any point than the standard thickness given in table No. 2." It seems to me that would be a little difficult to carry out, although, of course, it is a good thing. We often test pipe by rolling it to find whether it is of uneven thickness; but it would be rather difficult to caliper pipe at the center and find out just what the thickness is.

Under the head of "Special Castings," near the bottom of the same page, it reads that they "shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications"; and it says elsewhere, or has been stated by the Committee, that the weight of specials should be determined in advance. I do not see, unless the length of the branches is given, how the weight of the specials can be determined.

With reference to how the pipe shall be cast, it seems to me that perhaps on the whole it would be better to have it cast bell down and get a good bell. But, on the other hand, we often get a good many poor spigots, and in my experience I have had very few cracked bells. There have been a great many more cracked spigots than cracked bells. If they were cast bell end up, I should expect better spigots.

Referring to testing pipes, the specification says, "They shall also be subjected to the same proof by water pressure and hammer test after their delivery and before their final acceptance, if required by the engineer." It does not say at whose expense. I suppose that is after they are delivered to the town or city where they are to be used, but it seems to me something should be put in to make that a little more definite.

It says that castings shall be "delivered sound and perfect," and it there refers to the way in which they shall be cast. There is one trouble in connection with the receipt of pipes when they are not inspected at the foundry. They may be all right when they leave the foundry, but when they are put upon the railroad there comes in the question of a divided responsibility; and in my experience I have found that by the time the pipes were laid along the trench there were often many cracked spigots. The makers would insist that the

pipes were all right when they left the foundry, and say that the cracking took place on the railroad cars; and I presume this may be to a large extent true. In switching and shifting, the cars are often thrown violently together. As there are generally two tiers of pipe upon a car, the spigots come in contact with the pipe opposite, and very likely a good many spigots are cracked in this way. And then, again, I have seen a good many pipes that were badly cut into by the fin on the bead of the adjoining pipe. The fin would be very hard, sharp, and thin, and it would cut not only through the coating, but into the pipe itself. Of course, being on the outside, it would not do the damage that it would if it were on the inside, but at that particular point it cuts through the coating and allows corrosion to begin.

It seems to me that the dimensions of the depth of socket and the joint room agree very well with average practice, and I think that the Committee has done good work and deserves our thanks for putting this matter in such shape as it is now in; and I believe that with the changes that are likely to be made we shall have made good advance in pipe specifications.

MR. E. H. GOWING.* I should like to say a few words about this matter of thickness of pipe, in reply to the suggestion made that it is perhaps unnecessary to have more than one size, and have that heavy enough for everything. That might be very well in places where people have lots of money; but some of us are poor, and cannot afford it. The 8-inch pipe which the gentleman said weighs six hundred pounds to a length will, at the present prices, cost ten cents a foot more than another class of 8-inch pipe which it would be quite proper to use in a great many places. That means five hundred and twenty-eight dollars a mile, or for a ten-mile system in a small country town it would mean over five thousand dollars. In many places five thousand dollars means much more than it does to the large gas companies or the water departments of large cities; so that if lighter weights can be used in these small places, I believe they should have a chance to get them. I think practice has abundantly proved that the lighter weights are practicable under many conditions, and so I want to support the Committee heartily in their plan of different classes for different situations. Pipe laid in a city street, particularly gas pipe laid near the surface, is subjected to strains which water pipe laid in a 6-foot trench in a country town

* Civil Engineer, Boston, Mass.

never meets. It seems to me that the man who orders the pipe should have sense enough to order a heavy weight pipe for a city street, and a lighter pipe for a country road where there will be no strains due to settlement, where there will be no teaming to affect it, and where it can remain in its position for years without ever being subject to outside strains of any kind. I have some other things which I may want to speak of later, for certainly this discussion will have to go over to another day, and I will say no more now.

(*January 8, 1902; discussion continued from December meeting.*)

MR. COFFIN. I believe the Committee has nothing new to offer to-day, Mr. President. Since the last meeting a few written discussions have been received, but the Committee has taken no further action, and we are waiting for further discussion before we submit our final report.

MR. BRACKETT. As Mr. Coffin has stated, we have received a number of discussions, and possibly if they are read it may bring out further discussion here. I may say that we have received letters during the past month from the pipe manufacturers, stating that they have not yet been able to get together for a conference, but a meeting has been appointed to be held on the 16th of this month. After that meeting we expect to have a conference with a committee representing the pipe founders, and then may be able to report the specifications in somewhat more final form.

MR. LEONARD METCALF.* After the excellent report of our Committee I hesitate somewhat, Mr. President, to appear to criticise it, but there are certain points in the specifications on which I had hoped there might be some discussion. Perhaps I have viewed the specifications from a little different standpoint from that of many members, that is, from the standpoint of the small purchaser, who wishes to be safeguarded in the quality of the pipe which he buys in the open market, just as is the large city which has its engineers, and which has an inspector at the foundry: and in that connection I had certain suggestions I wanted to bring forward as to changes in the specifications.

First of all, there are two or three paragraphs in the specifications as printed where the matter of tests is left to the discretion of the engineer. If I remember rightly, the hydrostatic test is the only

*Civil Engineer, Boston, Mass.

one which is definitely required of the foundry. The hammer test, in conjunction with the hydrostatic test, is left to the judgment of the engineer, as is also the making of tests of the properties of the cast iron by means of little beams, — transverse tests. Now, it has seemed to me that if it is worth the while of the large cities, which are purchasing large amounts of pipe, to have these tests made, it should be equally worth the while of the small consumer to know that he is getting pipe of the grade called for in these specifications, an equally good pipe, in short; and the only way in which he can do that is to have tests made in a similar manner.

In many cases, — perhaps in most cases, — it would be out of the question — according to his way of thinking, at any rate — for him to employ an engineer and to have a pipe inspector upon the ground; and it seems to me that the specifications should be drawn in such a way that if he calls for pipe under these specifications he will get the same kind of pipe that the larger cities, buying pipe under these specifications, would get through their engineers.

Taking up these points one after the other, briefly; — I will refer first to the paragraph under "Quality of Iron," the beginning of the second paragraph: "Specimen bars of the metal used, each being twenty-six inches long by two inches wide and one inch thick, shall be made without charge as often as the engineer may direct" (*i. e.*, left optional with the engineer). In other words, if there is no engineer, the foundry will not make such specimens and will not test them. I would therefore suggest that in that paragraph such a sentence as this might be embodied: "In default of definite instructions the contractor shall make and test at least one specimen bar from each heat or run of metal."

Taking up the hydrostatic test as the next point, making the hammer test in conjunction with the hydrostatic test, I would strike out the clause, "If required by the engineer," and make it read that the pipe shall be tested by hydrostatic pressure, — "And they shall also be subjected to a hammer test under this pressure." With the inspector on the ground, of course, that may be dispensed with, so that the engineer of the large consumer may use his own judgment; but under other circumstances the test would be made.

The third point is in regard to the method of quoting prices upon the pipe and making settlement for it, — whether we should use the long or the short ton. It seems to me it would be desirable to have that appear in the specifications as a mere matter of convention and

convenience; and to this end I would suggest in the paragraph under "Weighing," that some such clause as this might be inserted: "Bids shall be submitted and final settlement made upon the basis of a ton of two thousand pounds."

Finally, under the heading "Contractor to Furnish Men and Materials," I would change the last half of the paragraph so as to read, "And if the pipe is not inspected at the works by the engineer, the contractor shall furnish a sworn statement that all of the tests have been made and the requirements fulfilled, and if the pipe is specially cast to fill a given order the specific results of the tests shall also be submitted." This would do away with the complaint that the manufacturer might make that he could not keep track of the individual pipe that he puts into stock and of the tests which he made of the material which went into this pipe. Where the pipe is taken from stock, the consumer would merely know that all of the pipe which is in stock had passed the tests, but the large buyer, for whom the order is specially cast, would, of course, have the specific tests covering that pipe.

Referring to the hydrostatic tests which are required, it seems to me that the pressures which are stated here are small, particularly for the lighter weight pipe. Certainly, in many of the smaller water works which have been built in this country, very much lighter weights have been used than — or, let me put it in this way, — as light weights as Class A pipe of this table have been used for pressures of 100 to 125 pounds, under specifications requiring a hydrostatic test of 300 pounds per square inch. I have taken the figures which are given in these tables for the thickness of pipe, and figuring backward, making use of the factor of safety of 5, which is suggested, have figured out the pressures which the pipe should stand. Upon that basis it would be entirely safe to use very much higher hydrostatic pressures than are called for under this test. Indeed, it might well be as high as 300 pounds for pipe of all classes up to 10 or 12 inches. That is, I find, for instance, in Class A, that on the 4-inch the strength is five times 561 pounds; the 6-inch, five times 418; the 8-inch, five times 346; the 10-inch, five times 310; the 12-inch, five times 270 pounds, and so on. So it seems to me that the hydrostatic pressure might well be increased considerably beyond the limits suggested in this report.*

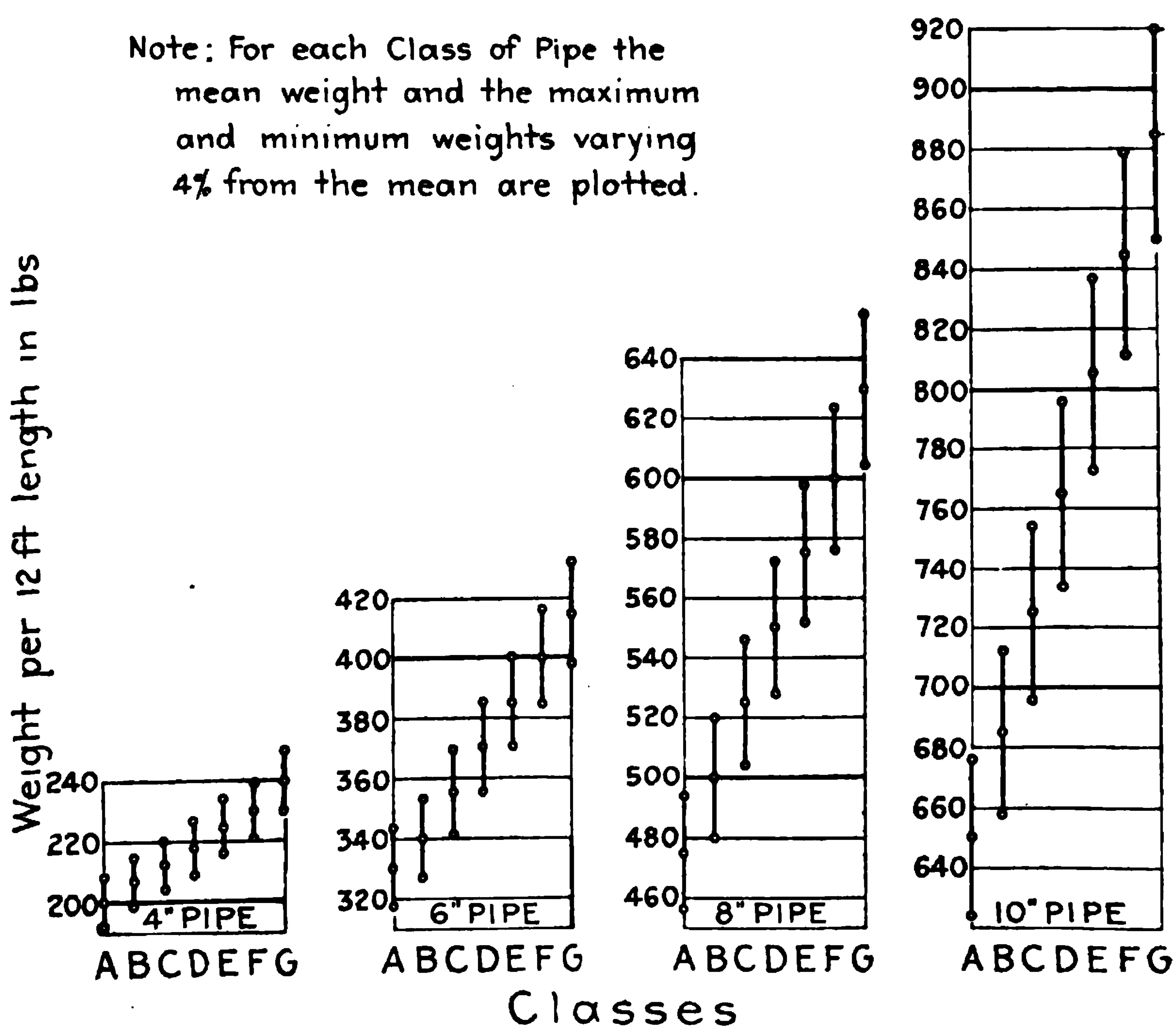
That brings up the question as to the number of classes of pipe

* See Table B, page 123.

— Diagram —
SHOWING THE
Variation in Weights
— AND THE —
Overlapping of Individual Classes of Pipes

UNDER THE CLASSIFICATION SUGGESTED BY
The New England Water Works Association
Committee on Standard Specifications for Cast Iron Pipe

DECEMBER 11, 1901
LEONARD · METCALF MARCH, 1902



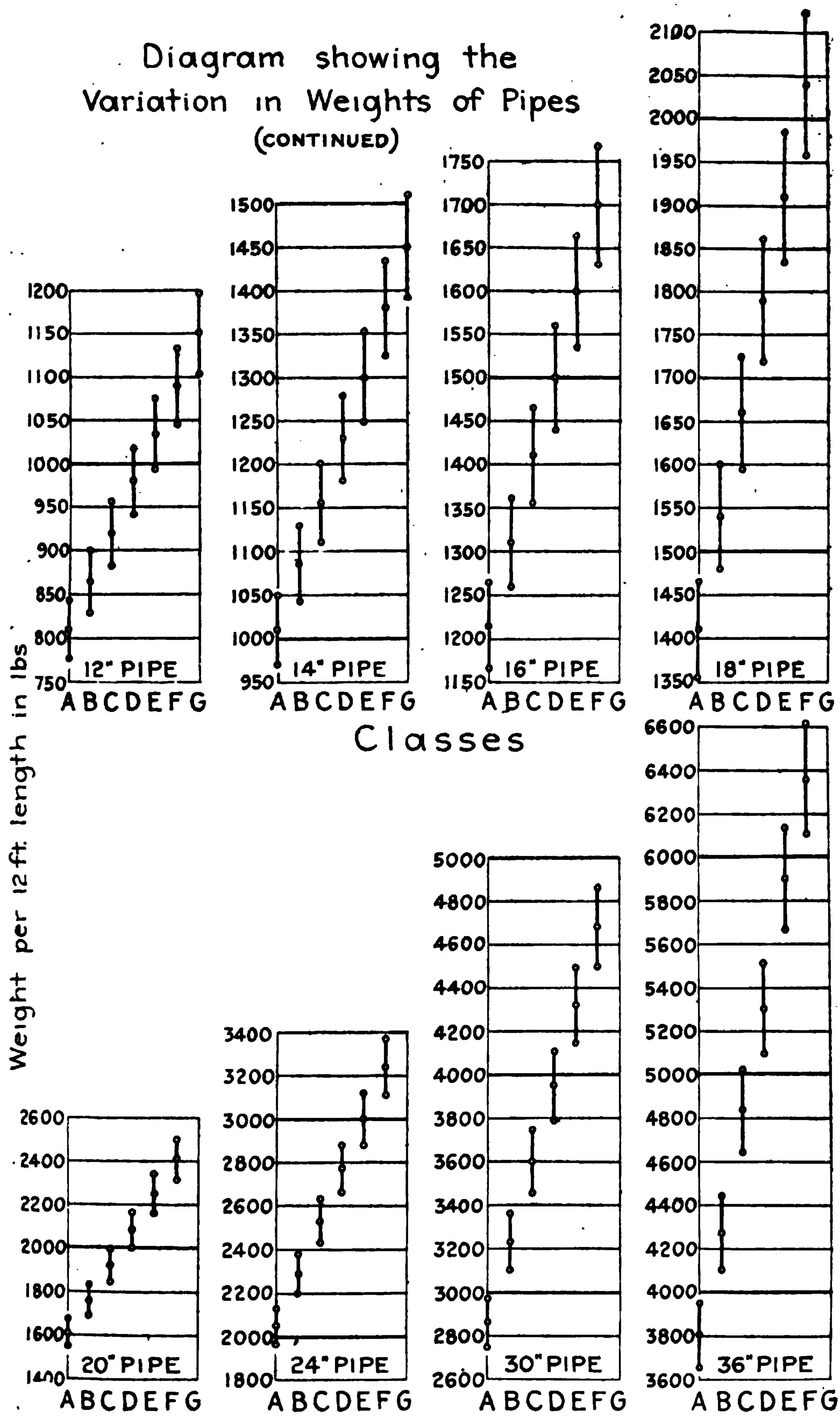


Diagram showing the
Variation in Weights of Pipes
(CONTINUED)
Weight per 12 ft. length in lbs.
Classes
12" PIPE
14" PIPE
16" PIPE
18" PIPE
20" PIPE
24" PIPE
30" PIPE
36" PIPE
ABCDEFG

which we should have. Under the tables which have been submitted here, and using an allowable variation on individual pipe of four per cent. each way, pipe of one class lap over into the next class; that is, the minimum weight of one class is less than the maximum weight of the class below it, and in some cases the smaller pipe even lap into the second class beyond. The accompanying diagram, pages 116, 117, illustrates this point. It seems to me that the necessities of ordinary practice would be met, probably by two classes but certainly in the smaller pipes by three classes. And I would suggest to that end that the Classes A, C, and F should be used, omitting Classes B, D, and E. In that way all overlapping would be avoided, and we would n't find the condition which might prevail under these specifications, — that is, a lighter pipe actually being used on the high service of a city than is used in the low service of the same city, as a result of this four per cent. allowable variation. If we were to adopt three classes, instead of five classes, we could then use as a hydrostatic pressure test for those three classes, — for the small pipe up to, say, 12 inches in diameter, 300 pounds on Class A and Class C, and 350 pounds on Class F, as is suggested by your Committee; on Class C, for all pipes above 12-inch, 250 pounds, and on Class F, for all pipes above 12 inches in diameter, 350 pounds, as the Committee suggest. Upon Class A we would, however, have to decrease the hydrostatic pressure test gradually; that is, from 300 pounds on the 12-inch diameter to 250 on the 14-inch and 16-inch, 220 on the 18-inch, 20-inch, and 24-inch, and 150 pounds on the sizes larger than 24 inches.

Another thought suggested itself to me in connection with the larger pipes. It is not a question with which many works have to concern themselves, and I therefore hesitate to mention it, yet it occurred to me that it would be well for the Association to recommend that for pipes over fourteen inches in diameter new works at least should adopt but one or perhaps two diameters for different weight pipes of the same nominal diameter, and avoid the necessity which exists under the proposed specifications of having three different sizes of pipe of the same nominal diameter.

The formula for thickness of pipe which is suggested by the Committee seems to me to be a thoroughly rational one, and gets away from the inconsistencies of some of the older formulæ which have been used, in which a constant was added in order to prevent breakage or to cover the danger of breakage in the shipment of

pipe. In this connection it may be of interest to mention a paper that Mr. N. Henry Crafts published, in the form of a report to the town of Watertown, in 1876, which, apparently, has had considerable influence in determining the weights of the smaller sizes of pipe that have been used in many of the small works that I speak of. I have with me a list of the weights which have been used by Mr. William Wheeler in his practice in some fifteen or twenty works, which are very much like the lighter weights that Mr. Coffin spoke of at one of the meetings during 1900,* and which I should be very glad to summarize for publication in the JOURNAL if you think it would be of interest.

This is all I have to say, Mr. President.

MR. COFFIN. I did not expect to take any part in this discussion to-day, but Mr. Metcalf has raised several interesting points, about some of which I quite agree with him, and I would like to say something about them just at this time. The Committee have had a good many very valuable suggestions presented to them, and will consider all of them; but I would ask the members to remember that there are several points of view in this matter, and the Committee, whatever the personal preferences or ideas of its individual members may be, has to consider them all. What would suit one person would not suit another, and it has been the endeavor of the Committee right along to get a specification which might, on the whole, be acceptable to everybody. In saying this, speaking just after Mr. Metcalf has spoken, I do not mean to be understood as being antagonistic to any of the points he has suggested in the way of changes. The Committee will consider them, but still it may be that, while some of the suggestions are very valuable, — looking at the subject from one point of view, — the Committee may not be able to recommend the adoption of any of them.

He has spoken of the weights in the different classes, and I want to refer to that now, while we are all here, hoping that there may be further discussion upon it. The matter has been very thoroughly considered in Committee, and while some of us would prefer more simplicity in the classes, still it seems to me that if we are going to prepare a list of weights which would be acceptable as a general list for specifications, we must have more than three classes; not that any one man may use as many classes as another, but that any

*See "A Few Notes on Cast-Iron Pipe," Journal New England Water Works Association, September, 1900, Vol. XV, p. 38.

engineer in buying pipe may be able out of those classes to select a list which will suit his practice. For instance, I could pick out of that list three classes which would cover everything I should care to use. Another engineer might also pick out three classes, but would, perhaps, want different classes from mine. He might want heavier pipes for certain cases than I would, or he might want lighter pipe. That was the idea of having all these classes.

It is very easy to see that it would be better, if possible, to have fewer classes, more especially, I think, on account of lettering the pipe. If the founder has to letter the pipe, he does n't know when he casts his first pipe in any lot just where he is going to strike; it is a matter of experiment, as I understand it. He may cast pipe intended for Class B and they may run over Class B into Class C, or possibly run under into Class A; and if the letter is cast on it, of course that fixes the class and he must lose the margin, or it must be arranged in some other way. That, I should imagine, would be one of the criticisms that the founders will make, and it is, as far as I can see, the worst objection to our classification. I therefore wanted to explain why the weights were classified in this way.

I was very glad to hear Mr. Metcalf speak of his practice in using different weights of pipes. I suppose you have noticed in reading the report that the Committee had tried not to commit the Association to the endorsement of any particular weight of pipe for special work or special conditions. The Committee has explained how the classes have been computed, but in the specifications themselves there is nothing to commit the Association to any weight for any pressure in any class. I think it is very desirable to have some discussion on that point, and I, for one, would be very glad if Mr. Metcalf would tabulate his weights and have them go into this discussion.

Mr. Brackett. I would like to ask Mr. Metcalf whether he would build a reservoir or a filter gallery or a system of sewerage without inspection, and take the sworn statement of the contractor that the work had been carried out in accordance with the specifications. That, I understand, is what he proposes to do in the case of cast-iron pipe. I do not think you can be sure of getting good work unless you employ an inspector to see that it is done in accordance with the specifications. Some of the points which Mr. Metcalf has mentioned were intended to be covered by the specifications, and I think he will find that they are. I may say that in general I agree with his suggestions.

Mr. Metcalf (by letter, March 27, 1902). In further comment upon the subject of the weight of cast-iron pipe, I send herewith a table of weights of cast-iron pipe according to different authorities (Table A, page 122).

Without attempting to state specifically all of the weights of pipe used by Mr. William Wheeler upon different water works constructed by him, I have tabulated under the head of "General" and "Heavy" the two classes of weights ordinarily used by him, — the first for service in small communities; the second in cities where considerations of heavier street traffic, greater liability to future disturbance by excavations in the street, and heavier pressures for high service, govern.

The class "General" has been used even under such high pressures as those prevailing at Winchester, Ky., a city of about six thousand inhabitants, in which the pressures have the following range: —

On the 12-inch pipe, from 30 to 60 pounds per square inch.
On the 10-inch and 4-inch pipe, from 45 to 125 pounds per square inch.
On the 8-inch and 6-inch pipe. from 50 to 75 pounds per square inch.

The class "Heavy" was used, for instance, at Knoxville and North Knoxville, Tenn. (and other cities), where a population of about forty-five thousand or fifty thousand is supplied, and where the pressures range from thirty to one hundred and twenty-five pounds.

The weights used by Mr. Freeman C. Coffin are quoted from the Journal of New England Water Works Association for September, 1900, with the exception of those contained in the last column, marked "Lightest," which were kindly given to the writer by Mr. Coffin.

The weights suggested by Mr. N. Henry Crafts were taken from his report to the town of Watertown, Mass., dated July, 1876.

It seems hardly necessary to reply to the question of Mr. Brackett, as to whether the writer "would build a reservoir, or a filter gallery, or a system of sewerage, without inspection, and take the sworn statement of the contractor that the work had been carried out in accordance with the specifications." He would certainly not to do so, and as Mr. Brackett doubtless knows, he is a thorough believer in the careful inspection of all materials of construction, as well as the actual execution of the work.

Yet the fact should not be overlooked, as previously stated by the

TABLE A.—WEIGHTS OF CAST-IRON PIPE ACCORDING TO DIFFERENT AUTHORITIES.

COMPILED BY LEONARD METCALF, MARCH, 1902.

Diam. of Pipe.	William Wheeler.				Freeman C. Coffin.*							
	General.		Heavy.		Light.		Standard.		Heavy.		Light	
Inches.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	
3	14	168	14	168	..	..	..	..	..	..	..	
4	17	204	18	216	17	204	19	228	22	264	16.4	
6	28	336	29	348	27	324	30	360	35	420	26.3	
8	40	480	42	504	40	480	45	540	50	600	36.7	
10	53	636	57	684	54	684	60	720	70	840	50.0	
12	67	804	74	888	68	816	80	960	90	1 080	64.1	
14	..	1 116	93	1 116	85	1 020	100	1 200	115	1 380	79.4	
16	..	1 368	114	1 368	105	1 260	125	1 500	145	1 740	101.2	1
18	..	..	137	1 644	120	1 440	150	1 800	175	2 100	114.2	1
20	..	.	162	1 944	140	1 680	175	2 100	205	2 460	133.6	1
24	..	..	..	..	185	2 220	225	2 700	270	3 240	..	

* See JOURNAL New England Water Works Association, September, 1900. "Light," safe for 100 feet head; "Standard," safe for [redacted] feet head; "Heavy," for city use and higher heads than 300 feet.

writer, that with much of the pipe that is laid there is no inspection of the pipe prior to its superficial examination on the ground where it is to be used.

Hence the writer is of the opinion that the Association should do all in its power to maintain and improve the standard of the product turned out at the pipe foundries in the interest of the small consumer as well as of the large.

The following tables, bearing upon the hydrostatic testing of cast-iron pipe, are appended in amplification of the writer's remarks upon this subject.

TABLE B.

COMPUTED* BY LEONARD METCALF, FEBRUARY, 1902.

Diameter, Inches.	Class A. Thickness, Inches.	Class A. Allowable Static Pressure, Lbs. per Sq. Inch.	Class C. Thickness, Inches.	Class C. Allowable Static Pressure, Lbs. per Sq. Inch.	Class F. Thickness, Inches.	Class F. Allowable Static Pressure, Lbs. per Sq. Inch.
4	0.34	561	0.36	594	0.40	660
6	0.38	418	0.42	462	0.48	528
8	0.42	346	0.48	396	0.56	462
10	0.47	310	0.53	350	0.63	416
12	0.49	270	0.57	313	0.69	379
14	0.53	250	0.61	288	0.75	354
16	0.55	226	0.65	268	0.80	330
18	0.57	209	0.69	253	0.86	316
20	0.60	198	0.72	238	0.92	304
24	0.64	176	0.80	220	1.03	284
36	0.79	145	1.02	187	1.37	251
48	0.95	131	1.25	172	1.70	234
60	1.10	121	1.50	165	2.10	231

* By slide rule.

HYDROSTATIC TESTS SUGGESTED BY L. METCALF.

Diameter of Pipe.	Pressure (Pounds per Square Inch). Class A.	Class C.	Class F.
3 in. to 12 in., inclusive	300	300	350
14 in. and 16 in.	250	250	350
18 in., 20 in., and 24 in.	200	250	350
30 in. and over	150	250	350

MR. JAMES H. HARLOW* (by letter). I am in receipt of an advance copy of the report of the Committee on Standard Specifications for Cast-Iron Water Pipe.

In looking over the report somewhat hastily, I have been struck with the weights recommended by the Committee in Table No. 2. In this connection I would follow the Committee where the Committee says, "Believing that to the engineer or superintendent should be left the final decision as to the thickness of weight of pipe suitable for the particular place in which it is to be used."

I note the Committee recommends an allowance for water hammer of one hundred and twenty pounds in the small and about seventy pounds in the larger sizes. From my experience on the pipe lines of the Pennsylvania Water Company, it seems to me this water-hammer allowance is far in excess of the necessities of the case. The Pennsylvania Water Company's pipe lines are subject to a static pressure of about one hundred and fifty pounds per square inch. This, during the day-time period of greatest demand, is reduced to about one hundred and thirty-five pounds. As will be seen by the daily record enclosed,† we have no hammer in our lines, and in the experience of twelve years since this work has been constructed, I do not recollect of a water hammer that would exceed ten pounds, as shown by the recording gauge.

Again, it seems to me that the .25 of an inch to be added to the calculated thickness of pipe is hardly necessary.

With the exception of 4-inch pipe, the weights given under Table No. 2, Class C, are about the weights used by us, in the place of Class G, shown in the table.

The Pennsylvania Water Company has a mileage exceeding one hundred miles of pipe, varying in size from six inches to forty-two inches.

If pipes of Class G had been used, the interest on the excess cost would have been between four thousand and five thousand dollars per year, while the cost of making repairs to breaks in pipes, other than those caused by sinking of sewers, etc., has been less than one per cent. of this sum.

I believe, from our experience, that the weights of the pipes as given by the Committee can be very materially reduced.

We find that $t = \frac{hd}{13\,500}$ to be safe, in which t = thickness of pipe in inches, h = head in feet, and d = diameter in inches.

* Civil Engineer, Pittsburg, Pa. † Not reproduced. — EDITOR.

I am pleased to see that the Committee recommends that the outside dimensions of the pipe are to be standardized, making the variations for the several thicknesses on the inside of the pipe, as this will enable special castings to be standardized also.

MR. BRACKETT. If no one else desires to say anything at this time you may be interested to hear some of the written discussions which we have received. To show the interest which is taken in this question, not only here but abroad, I will read the following from the British Association of Water-Works Engineers: —

LONDON, December 17, 1901.

DEXTER BRACKETT, Esq.,
Boston, Mass., U. S. A.

Dear Sir, — I am much obliged for your letter enclosing a copy of the report of your Committee on Standard Specifications for Cast-Iron Pipe, which was submitted to the New England Water Works Association on the 11th inst. I much regret that this was not forthcoming for the consideration of our Association at their meeting on the 7th inst., more particularly as in the course of the discussion on that occasion the question of standardizing cast-iron pipe dimensions, etc., was strongly urged by many of the speakers, and was, in fact, referred to our Council for further consideration. . . . I should like to ask you, as one of the Committee, whether there would be any objection to our publishing this report, and also whether you could let me have, at an early date, a record of the discussion which took place at your meeting.

I am sure my Council will highly appreciate the opportunity of enabling the water-works engineers in this country to coöperate with their brother engineers in America both in connection with this subject and any other of the many problems which from time to time call for solution at their hands.

Thanking you on their behalf for your interest in our proceedings, which I am sure will be heartily reciprocated, I remain,

Yours faithfully,

PERCY GRIFFITH, *Secretary,*
The British Association of Water-Works Engineers.

MR. BRACKETT. I have a discussion from George E. Manning, of New London. I am not acquainted with the gentleman, but I judge from what he has written that he is familiar with the manufacture of pipe.

MR. GEORGE E. MANNING * (by letter). The feature of the design which provides that the outside diameter for each size shall be uni-

* Civil Engineer, New London, Conn.

form and all changes of thickness made by changing the inside diameter is to be commended, not only from the pipe-layer's point of view, but because the manufacturer can consider it a concession to his interests. Changes of the inside diameter can be easily made in a few minutes; but to change the outside diameter requires the casting of an iron pattern and the turning of it down in a lathe to the proper size, and if three pipes are cast in one flask, as is the practice for small sizes in some foundries, three patterns must be made.

A foundry cannot give a low price and go to this expense for a small order.

The extra patterns, which the other method requires the maker to provide, deteriorate from rust when not in use almost as fast as by use.

There are three methods of making the molds for cast-iron water pipe.

1. *Dry-sand molds*, used for straight pipe.

2. *Loam molds*, used for large special castings. In this case a rough form is built out of bricks. This is covered over and brought to the exact shape desired with a clayey material, which, when baked, is a low grade of brick itself. A loam mold is expensive to make, but is quite sure to give a good sound casting.

3. *Green-sand molds* are used for all small special castings. This is the process in use in all iron foundries. The Association should not adopt a standard specification that required the maker to obtain, in writing, permission to use green-sand molds for small specials.

There has been a great deal said as to which end of the straight pipe should be cast down. An examination of the scrap heap at a pipe foundry will show that this is one of the most important items of the specifications. The carbon, silicon, etc., which are constituents of all cast iron, are of less specific gravity than the iron itself. When the cast iron is in a fluid state these lighter parts are constantly rising toward the surface. When the spigot is cast up, the runners cover the upper surface of the end of the pipe so well that the lighter matter readily rises into the casting head, leaving the pipe itself in good condition.

With the hub end cast up, the runners cover but a small part of the end of the hub, and the bottom of the socket also provides a lodging-place for the cinder. The hub of a pipe cast with that end up will, in almost every case, show, when broken, holes and

collections of cinder. When subjected to the proof of three hundred pounds to the square inch hydrostatic pressure, leaks will frequently show at once, but in many cases the water will begin to come through only after the pipe has been under the pressure two or three minutes. Upon examination it is often found that the passage for the water is several inches long from the point of entrance to the outlet.

All makers cast large pipe with hub end down, and some cast all sizes that way. A pipe maker who has the facilities for doing the work both ways will, if he has had experience with inspectors, usually prefer to make the pipe hub down for rigid inspection; for he knows there will then be fewer rejections.

The hydrostatic test, or proof of the pipe, is a most important item of the specifications. Where a good inspector is not standing by, however, it is often little more than a farce. More pipes are cast at some foundries than can be put through the proving press, if sufficient time is given to each one. The standard specification of this Association should provide that the pressure be held for at least one minute.

Providence and other cities where Mr. Shedd has been the engineer employed are using pipes with a depth of bell much less than that given in the table. If a depth of two and a half inches gives good joints, why buy iron to make a depth of three inches? No more lead is used for the deeper joint, I am told, but the difference is in the amount of yarning used. This, I am told by men who have calked both kinds of joints, tells against the deeper joint. It is more difficult to compact the lead against the larger quantity of yarn.

A part of the depth of the socket is to provide for irregularities in grade, and for all slight changes in direction. If the end of the spigot is drawn away from the bottom of the bell on one side only one-eighth inch for each two inches of the diameter, a change of direction of three and one-half degrees is made. Perhaps that is nearer to a straight line than the work can be done in many of the hilly streets of New England cities; but in some places, all street work is now laid out with so much care that a line of pipe can be laid within that limit.

The curve of large radius, shown at the bottom of the bell in the drawing, is correct for the design of special castings cast in greensand molds; but the method of making the different parts of a dry-

sand mold for straight pipe cast bell end down is such that a shape like that shown must be made with the trowel, — extra work, for which the socket maker is not paid and so seldom does. The bead at the spigot end can be made in a shape to correspond, with advantage to both maker and user. The change in the bead suggested is a triangular instead of a nearly half-round shape, when shown in section, — the largest diameter through the bead being nearly at the end of the pipe, and the end nearly square across. When joints are made with pipes having the sharp corners suggested, instead of a round-cornered design, there is more room for the yarn, and a smaller quantity can also be used with more confidence that it will not let the lead run through, so that less depth of socket is required.*

Under the present high-pressure methods, cast-iron pipes are generally shaken out of the molds too hot — often red. It would be hard to say just how much difference this makes; but there can be no doubt that cooling quickly causes the crystals of cast iron to be inferior in quality, and sometimes a condition of strain within the casting itself. The writer has seen a 30-inch pipe, one and one-eighth inches thick, crack open in two places, from one half to two thirds its length, at the bell end, when under less than three hundred pounds pressure, the sides of the cracks at the end of the pipe remaining rigidly about one and one-half inches apart. It was a pipe shaken out while still red; and there appeared to be no other reason for its behavior than the unequal contraction in cooling. This pipe had been rejected because the same condition had been indicated by its being badly out of round.

Some foundries practice the making of two pipes in the same flask in one day; others one per day, while others have provided two full outfits of flasks and core-bars, and make casts in them on alternate days. The pipes remain in the flasks over night, and are perfectly cold when shaken out. This process must give the best quality of pipe, other conditions being the same. As all the flasks and core-bars are of the same temperature when the new molds are made, the pipes are more uniform in weight. Many of the defects of casting are thus avoided.

It is provided that specimen bars shall be cast without charge. It would not be too much to specify that the use of a standard testing

* See "A Discussion of Pipe Joints," submitted by Mr. Manning for the February meeting, and printed on page 130. — EDITOR.

machine for breaking the bars should be furnished by the contractor. Otherwise it might be held by him that the clause that provides that he shall furnish the tools for the inspection of pipes did not cover the machine for breaking specimen bars. The breaking of these bars is not of vital importance, but it is thought that by means of it a better knowledge of cast iron will be gained by all concerned.

It is desirable also that the Association should, if possible, do something to promote the chemical examination of the mixtures for cast-iron pipe. A case in mind is what occurred at a foundry where nothing but 30-inch pipe were being cast. The mixture put into the cupola was brought from four different furnaces. For a thickness of seven-eighths inch and one inch the castings were good and sound, but for a thickness of one and one-eighth inches, less than ten per cent. could be accepted for several days at the start. The castings were porous and leaked badly through two or three feet of the pigots (upper) end when proved. This could not be helped by the inspector or buyer, but it was not pleasant for them to have it occur.

It is the writer's observation that good large and thick pipe cannot be made with the iron that will make good small pipe.

The metallurgical chemist's knowledge of steel is such that contracts are made which specify what per cent. of carbon and other ingredients it shall contain, according to the purpose for which it is to be used.

The large scale processes of making steel, such as the Bessemer open-hearth, or basic, have always been, and the reduction of the ores in the furnaces is now, as a rule, under the direction of metallurgists, and is conducted in a scientific manner.

The iron-founder's art is older than the science of chemistry. Its processes are still based largely on the traditions of the art. The services of a chemist are seldom employed. The olden-times iron-founder, who could tell all about cast iron from the appearance of the fracture of the pig, was successful as long as the pigs were all from the same ores and furnaces, but was at a loss when it came to using unknown pig iron.

It is to be hoped that the time will come, and probably the time is coming, when there will be a chemist in charge at the pipe foundry.

However valuable he might be to an ordinary foundry business, he would be particularly useful at a pipe foundry where the quantity

of iron used is large, a great many castings of the same size and thickness are made, and nearly all of the work is done by men who are to be classed as common laborers when compared with the molders in green sand. Such conditions are favorable for a scientific management. A metallurgist, trained in pipe making, would know what is needed to make a certain line of castings called for by a contract. He would select the mixture and give it the heat treatment needed. Instead of running the whole foundry force for several days on experiments, turning out pipes which are sent to the scrap-pile or accepted reluctantly by the inspector, the castings would be from the beginning as sound as the best made under the usual practice of the present.

The largest consumers can now make contracts for pipe under such specifications for the design, mode of casting, inspection, etc., as they wish.

By the use of standard specifications, adopted by this Association, the smaller consumers will be able to obtain, even for their yearly extensions, first, pipe that will always fit together; second, a saving in material and cost, through a better and a uniform design; third, an improved quality, by insisting upon the important clause that the pipe shall be cast bell end down, and not giving permission in writing for bell-end-up casting, except it may be for 4-inch pipe.

To obtain pipes of even thickness, free from defects and properly proved by hydrostatic pressure, it will always be necessary to have the services of a good inspector.

A DISCUSSION OF THE DESIGN OF LEAD JOINTS FOR CAST-IRON WATER PIPE.

[*Submitted for the February meeting of the Association, by George E. Manning.*]

Years ago, when the hub and spigot form of cast-iron pipes with lead joints was adopted, it was the practice to make the depth of socket much more than it is made now.

Twenty-five to thirty years ago, many miles of pipes were laid which had a depth of socket as small as two inches for the six-inch size. That was a bold departure from the general practice, but it does not appear that these joints have given any more trouble in service than the deeper ones have. But it was found desirable to increase the depth slightly, chiefly because hilly streets have made it necessary to have small deflections in a line of pipe.

All engineers came to have more confidence in the lesser depth, and a general tendency in that direction is to be noticed in all designs of late years, probably not so much in the larger as in the smaller sizes. But, as the greater part of the large sizes are under less pressure (that is, in gravity systems, perhaps not in pumping systems), they are less subject to water hammer, and, as a rule, can be laid in a more direct alignment, — curved pipes being used for changes in direction, — it would appear that a small depth of joint is as safe for the larger as for the smaller sizes.

Another consideration is, that for 24-inch and larger sizes, into which a man may crawl, a device can be placed on the inside of the joint that will keep the lead from running through, and thus do away with the yarning and the space that it takes up in the smaller sizes. This joint can be set up on the inside as well as on the outside, and thus affords better security.

As there are many members of the Association who have used, prefer to use, and will probably continue to use, a design for pipe having a depth of socket less than that suggested by the Committee on Standard Specifications for Cast-iron Pipe, a design and table of dimensions which embody this idea are submitted for consideration. It is based on the design of Mr. J. Herbert Shedd, which is in use at Providence, Newton, and many other places.

The dimensions shown will give at least two inches for depth of joints (including bead, yarn, and lead, as such), with a deflection of not more than three and one-half degrees in the alignment.

The tangent of $3\frac{1}{2}°$ being .06145 or $\frac{1}{16}$, one-eighth inch for each two inches of difference in the diameters is taken for the difference in depths of sockets.

Beginning with a depth of $2\frac{1}{8}$ inches for a 2-inch pipe, a 4-inch pipe will have a socket $2\frac{1}{4}$ inches deep, a 6-inch pipe, one $2\frac{3}{8}$ inches deep, etc. All changes in the corresponding outside dimensions of the hub for changes in diameter have the same relation to the depth of socket.

By having the inside of the pipe flare out a little larger at the joints, the waterway of the pipe line is not reduced when the pipes are not exactly centered from any cause. This flare can be easily made at the hub end, and seems to be worth having. A flare at the hub end only gives all the benefit in case the pipe is laid with the hub end toward the flow of water, and much of it in any case. As the flare at the spigot end is more trouble to make, and would

lead to more breakage in the thinner classes, it might not be well to insist upon it in all cases.

The function of the bead at the spigot is to keep the yarn from being driven through the joint when it is being calked. A shape like that shown tends to place the yarn exactly where it is needed and to resist its going any beyond. A half-round shape of bead will tend to let the yarn slide around it into the pipe. The mold for a pipe has to be parted at the largest diameter of the bead. When the part of the mold that forms the end of the pipe is flat, or nearly so, it can be made in a more economical manner by the foundrymen than the half-round shape can be.

Attention has already been called by the writer, in a previous discussion, to the nearly square inside corner of the socket. The slight slant at the end is the shape usually given to it by the socket coremaker, as it is thought that it can thus better resist the blow from the molten iron, falling from a height of twelve feet upon it.

If any lot of cast-iron pipe is examined, it will be found that the outside of the hub joins the shaft of the pipe with a slight offset and not with a tangent curve. The pattern is parted at that point, and if the hub pattern was given the thin knife edge when it was made, it would soon be broken so as to produce the offset in the casting. It will also be found that the straight parts of the sides of hubs are at an angle and not parallel with the shaft of the pipe. This is in order that the pattern may be drawn easily without breaking the mold. It may be of interest to state that the upper end of a pipe is a little larger in diameter than the lower end, for the same reason.

There has been a great diversity of ideas shown in the design of the lead groove. Many miles have been laid with pipe that had perfectly straight joints, *i. e.*, with no lead groove at all. A groove half-round in section has been used, which is probably, when set up, of no more use than no groove, and a waste of lead. A great many pipes have been laid that have a groove which is the reverse of the Boston design, — that is, the lead has to be set up against the shorter slant. Such a joint would seem to give the calker a harder task to set up the lead in its place than it gives the water to push it out of place.

The design shown has a groove with a slant on each side of the same length, viz., seven-eighths of an inch.

The length, over all, of a pipe is always made the same as the length of the flask in which it is cast, so that of two designs cast

at the same foundry, the one which has a hub that is, say, one inch shorter than the other, will have a laying length one inch greater.

Probably most men have not become trained to think in decimals of an inch, but mentally reduce such given dimensions to eighths and sixteenths. It is also doubtful if a pattern maker's shrink rule, divided into inches, decimally, is often found at a pipe foundry. There, too, such dimensions are changed, for use, into the common fractions. If any change is to be made in the direction of a decimal system, would it not be well to consider the metric system, which is coming into use in the shops, and will be in general use by machinists, probably, sometime?

Five centimeters are nearly equal to two inches. A pipe twenty centimeters in diameter would be only one-eighth inch smaller than an 8-inch pipe. By providing for a thicker class, — which would be seldom or never used, — the outside diameter being the same for all classes, as specified, the objection of a reduced capacity would be avoided in all ordinary cases. Fifty centimeters would be five-sixteenths of an inch less than twenty inches.

It would thus appear that a change could be made to the metric system with almost no inconvenience in any way. The new standard pipe would joint with the old as well as pipes from different foundries will with each other now. The difference between sizes, being five centimeters instead of two inches, would be as easy to carry in the mind.

In the table of dimensions which follows, outside diameters are not given, as they depend upon the thickness of the heaviest class that is decided upon finally. The inside diameter of the socket also depends upon the thickness.

$$\text{Depth of socket, } D = 2 + \frac{\text{Nominal diameter}}{2 \times 8}.$$

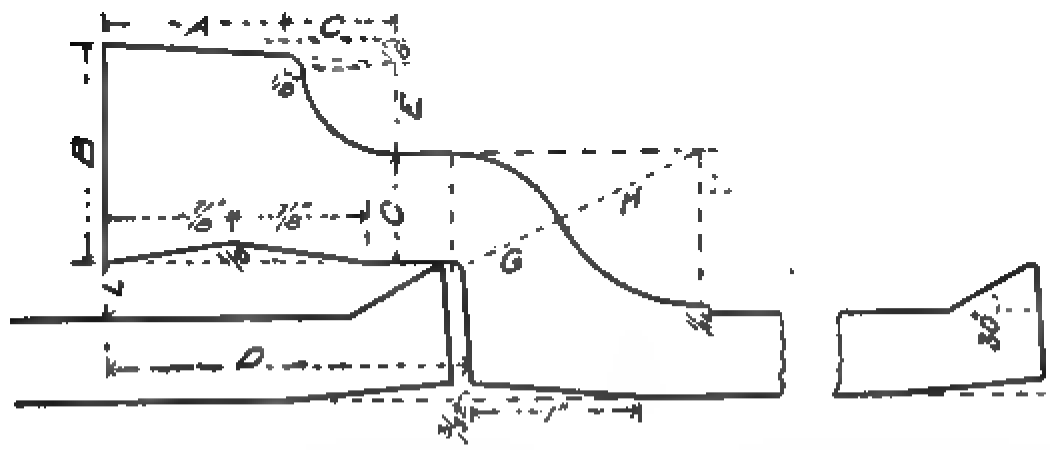
$$A = \tfrac{1}{2} D.$$

Thickness of end of hub $B = D - 1$ inch up to the 18-inch size, for which it is $2\frac{1}{8}$ inches, which is considered to be about as thick as there is any advantage in making it. But an increase of $\frac{1}{8}$ inch for each six inches on the diameter is suggested for the larger sizes.

$C = \frac{1}{2} B$.
Radius $E = \frac{1}{2} B - \frac{1}{8}$ in.
,, $G = \frac{1}{2} B + \frac{1}{16}$ in.
,, $H = \frac{1}{2} B + L - \frac{1}{16}$ in.
L = thickness of lead joint.

The recess of the lead groove should be from $\frac{1}{8}$ inch in depth for the smaller to $\frac{1}{4}$ inch for the larger sizes.

TABLE OF DIMENSIONS FOR HUBS, IN INCHES.



Nominal Diameter	4	6	8	10	16	18	20	24	30	36	42	48
Depth of Socket	2¼	2⅜	2½	2⅝	3	3⅛	3¼	3½	3⅞	4¼	4⅝	5
B	1¼	1⅜	1½	1⅝	2	2⅛	2⅛	2¼	2⅜	2½	2⅝	2¾
A	1⅛	1 3/16	1¼	1 5/16	1⅛	1 3/16	1⅜	1⅜	1 11/16	2⅛	2 1/16	2½
C	⅝	11/16	[illegible]	13/16	1	1 1/16	1 1/16	1⅛	1 3/16	1¼	1 5/16	1⅜
Radius, E	½	9/16	⅝	11/16	⅞	15/16	15/16	1	1 1/16	1⅜	1 3/16	1¼
„ G	11/16	¾	13/16	⅞	1 1/16	1⅛	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16
„ H	15/16	1	1 1/16	1⅛	1⅜	1 7/16	1 7/16	1½	1⅝	1 11/16	1⅞	1 13/16
Thickness of Lead, L	⅜	⅜	⅜	⅜	7/16	7/16	7/16	7/16	½	½	½	½
Outside Diam. of Pipe												
Inside Diam. of Socket												
Class A { Thickness												
Class A { Weight												
Class B { Thickness												
Class B { Weight												
Class C { Thickness												
Class C { Weight												

Hubs for special castings to have the same dimensions, except for depth of socket, which shall be one inch more, in all sizes.

MR. HORACE G. HOLDEN. I would like to ask Mr. Brackett what was the cause of the break of the large pipe on Causeway Street, in Boston, near the Union Station, some time ago: whether it was due to a defect in the casting originally, or whether the defect was caused in moving the pipe from the foundry to the cars, or in transportation on the railroad, or in moving it from the cars to the street, or in the laying of it.

MR. BRACKETT. That was a case where the pipe had been laid for many years in a soil which is more or less marsh mud, and the iron had deteriorated very much and turned to plumbago. I have had many cases in my experience where it has been very difficult to determine the cause of the break. Pipes that have been in use for a great many years without showing any visible indication of weakness have burst. There were about half a dozen breaks in the city of Boston last year on a line of 48-inch pipe which was only under about fifty or sixty feet of head, and the pipes were an inch and a quarter thick. These pipes should have withstood two hundred or three hundred pounds pressure. They had been in use since 1869, but not under quite as much pressure. A number of theories have been advanced as to the cause of the breaks, among others that slight cracks had been caused at some time by water hammer which were developed by the additional pressure.

MR. R. C. P. COGGESHALL.* Brother Holden may be interested in a case we had in New Bedford last April. It was on a 30-inch pipe, which had been laid in connection with our new works and was about two and one-half miles from the city. It had been thoroughly inspected. The pipe was fully an inch thick, and there was no way of accounting for the break, that I could see. There was a piece about five feet long and about two and one-half or three feet wide on the lower quarter blown straight out, just the same as you would take a cover off a stove, and there was n't a sign of a crack on the remaining part of the pipe. I have n't the slightest idea what the cause was.

MR. CHARLES K. WALKER.† I can tell you a story which I think will beat that. Last summer one of our gates, probably as good a gate as there is made, cracked from top to bottom under about one hundred pounds pressure. We had shut it off, and were repairing on the line below when the report came that there was a leak, and we went up and found the gate split from top to bottom right through the flange — an inch and a quarter flange. I have asked a good many experts what they thought about it, and they have all told me it was one of those cases which they did n't know about. I made up my mind I did n't know, and I can't find anybody so far who does. Now, if there is any gentlemen here who can tell me, I will treat him. [*Laughter.*]

* Superintendent of Water Works, New Bedford, Mass.
† Superintendent of Water Works, Manchester, N. H.

A MEMBER. Which way did it crack, up and down or horizontally?

MR. WALKER. Up and down. The gate had been shut for two hours, and all at once there was this big leak. We happened to be working near by, so we could shut it off, and there was n't any harm done.

MR. HOLDEN. How large a gate was it?

MR. WALKER. Twenty-inch. There was no wedging about it, and the iron was an inch and a quarter thick. There is another thing I want to say, about inspectors. We had about twenty-five leaks on a half a mile of 20-inch pipe, and the inspector who inspected it when it was laid is right here under my eye, and he is a good, bright man. [*Laughter.*] When we went to drive in the lead in a 4-inch bell, it went 'way in. We had to hustle round to shut it off when we struck it, because it was pretty full of gasket and there was mighty little lead. Of course the contractor was n't to blame, nor the inspector, — but there it was. If there had n't been but a little gasket in there we should n't have had any trouble. I am for a good, deep bell and plenty of lead. I don't care anything about the theoretical part of it, but any man who has had experience will say he had rather have more lead and less gasket. I want a 4-inch bell on a 20-inch pipe. I have seen enough trouble with short bells. A man who has been a superintendent for a number of years knows what trouble is when he gets it, but when you tell these experts about these things and ask them what is the cause, they say they don't really know. [*Laughter.*]

MR. F. F. FORBES.* I would like to ask Mr. Walker one question about the pipe line below the gate. How many feet fall was there, and was it abrupt?

MR. WALKER. I should think there was about thirty feet of fall.

MR. FORBES. I once had a similar experience to Mr. Walker's. I shut off the main where there was quite a sharp fall in the pipe, and the gate at the upper end of the main broke, something like in Mr. Walker's case. At first I could n't understand the reason for it, but I finally figured it out in this way: There was more than thirty-two feet of fall from the gate to where the blow-off in the main was, and when we opened the blow-off the whole column of water left the gate and very nearly a perfect vacuum was formed. Then for some reason or other that column of water broke, and this body of water went back like a cannon ball and struck the gate and

* Superintendent of Water Works, Brookline, Mass.

shattered it to pieces. This happened where there was n't more than fifteen feet head back of a gate made by the Boston Machine Company in 1874, a very heavy gate, one of the heaviest patterns. The gate was shut down carefully by hand, and there was no pressure whatever on the gate in turning it. The gate was broken to pieces, and the only explanation I could find was what I have stated.

MR. WALKER. I am very much obliged to the gentleman for telling me what the trouble was. He is the first one who could do it, and my offer to treat holds good. [*Laughter.*]

MR. H. A. FISKE. I should like to ask one question, which has been suggested by this water-hammer incident, in connection with some trouble we have had recently in a New England town from excessive water hammer caused by interior fire protection. I never knew of anything like it before, although we have fire protection devices of the same nature in other places. The water-works people in this town have had trouble from breaks caused by water hammer, and they claim that the device, which is a sprinkler system with air in the pipes, should not be allowed to be used, because it causes water hammer. The other side of the question is that the water hammer is not excessive, and is not more than is obtained in other places. I thought if any gentleman here had known of trouble from water hammer caused by fire protection devices, it might be interesting to bring the matter up. If the difficulty is with the device, and the water hammer is something which is going to cause trouble in other places either now or later on, I think we would all like to know it. I don't know as I have made myself clear, but I was wondering whether any of you gentlemen had had experience with water hammer causing breaks, and had taken action against devices, perhaps not fire protection devices, but elevator devices, or things of that kind.

MR. WALKER. I inspected the working of an hydraulic elevator in Worcester once, and the pressure went up from three hundred pounds to one thousand pounds, due to water hammer. I told them we did n't want any such thing as that in Manchester, for water hammer on cement pipe isn't healthy. [*Laughter.*]

MR. FISKE. Do you know of any action ever being taken by any water-works company in this matter? I should think the case you mention was rather exceptional, and I refer to a moderate water hammer, perhaps of two hundred pounds.

MR. WALKER. No, I never knew of any.

Mr. Fiske. I should think the water-works people would feel like sitting down on any device which causes excessive water hammer.

Note. — As stated on page 113, the manufacturers were to hold a meeting on January 16, at which they were to formulate their position; but a statement of their views has not yet been received from them, although requested several times, and each time promised "in a few days." — Editor.

THE MARLBOROUGH WATER WORKS.

BY GEORGE A. STACY, SUPERINTENDENT, MARLBOROUGH, MASS.

[*Read February 12, 1902.*]

The first action taken by the town of Marlborough towards introducing a public water supply was in 1873, when a committee was chosen to take the matter under consideration, and they secured the services of the late Phinehas Ball, C. E., of Worcester, and reported in 1874.

This report recommended a pumping station, distributing reservoir, fifty hydrants, and about eight miles of cement-lined pipe.

The attempts to introduce a public water supply met with the usual vicissitudes common to such undertakings, until 1882, when decisive action was taken and the work commenced, and the late M. M. Tidd was retained as engineer.

The city of Marlborough is situated at a considerable elevation above the immediately surrounding country, and the west end is built in part on four hills, viz., Prospect, Fairmount, Mount Pleasant, and Sligo; the last is the highest, and is about six hundred feet above tide water, and situated in the northwest part of the built-up part of the city; it is two hundred and sixteen feet above Main Street, at City Hall.

At the southwest base of Sligo Hill, and distant about fifteen hundred feet from its summit, is Lake Williams, a natural body of excellent water, the surface of which is about forty feet above Main Street, at City Hall (see plan, Fig. 1).

Considering its elevation, the city was very much favored by nature in regard to a public water supply, with one exception, and that was the quantity, — the watershed of Lake Williams being only two hundred and nineteen acres. But as all other suitable supplies were from two and one-half to five miles distant and at a very much lower level, and as Lake Williams would in all probability furnish a supply for a number of years at a comparatively small cost, it was decided to take this supply.

A pumping station (now called Station No. 1) was built on the

north shore of the lake; a reservoir of five and one-half million gallons capacity was constructed on Sligo Hill, ten miles of distributing mains were laid, and the water was turned on Main Street, on July 1, 1883. This work, and five miles of pipe laid in 1884, was done by contract; since that time all work except Pumping

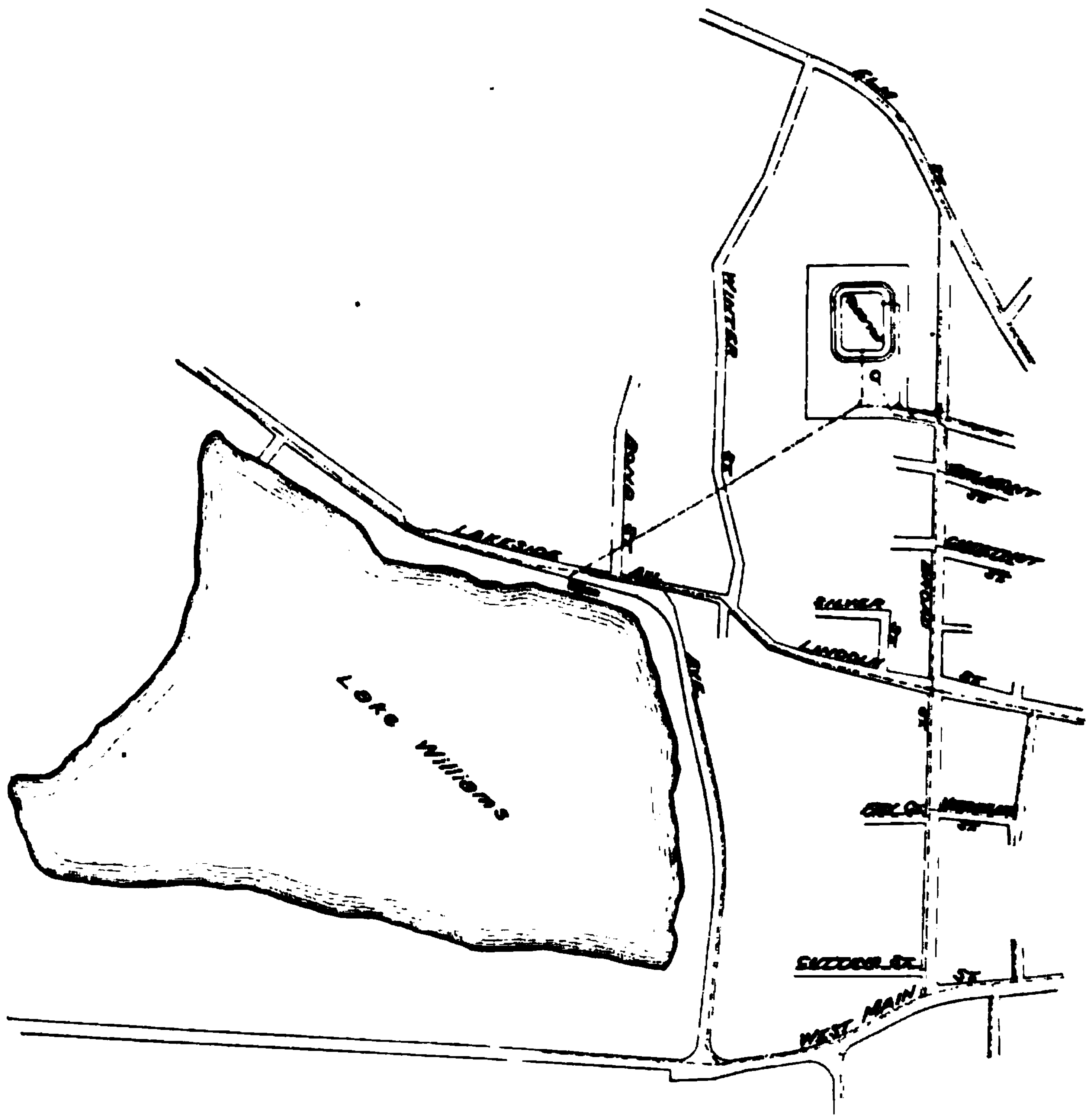


FIG. 1.— PLAN OF LAKE WILLIAMS, SLIGO RESERVOIR, AND CONNECTING PIPE LINES.

Station No. 2 and the standpipe has been done by the city with day labor.

In 1891 the low water in the lake demonstrated that we had about reached the safe limit of our supply, especially in a series of dry years.

After investigating all the available supplies and conferring with the State Board of Health, it was decided to construct a reservoir on Millham Brook in the northwest part of the city (see Fig. 2).

This brook, with its north branch, has a drainage area of about three and one-half square miles, which is very sparsely populated.

The dam was constructed of earth with a concrete core wall. It is 1 160 feet long on top, with a maximum height of twenty-six feet; the foundation of the core wall is on bed rock and in hard pan, and its maximum depth is twenty-five feet below the surface. A thirty-inch pipe extends through the south end of the dam on a level with the bottom of the reservoir.

The north end of the dam abuts on a ledge which rises from ten to fifteen feet above the top of the dam, and by the removal of about

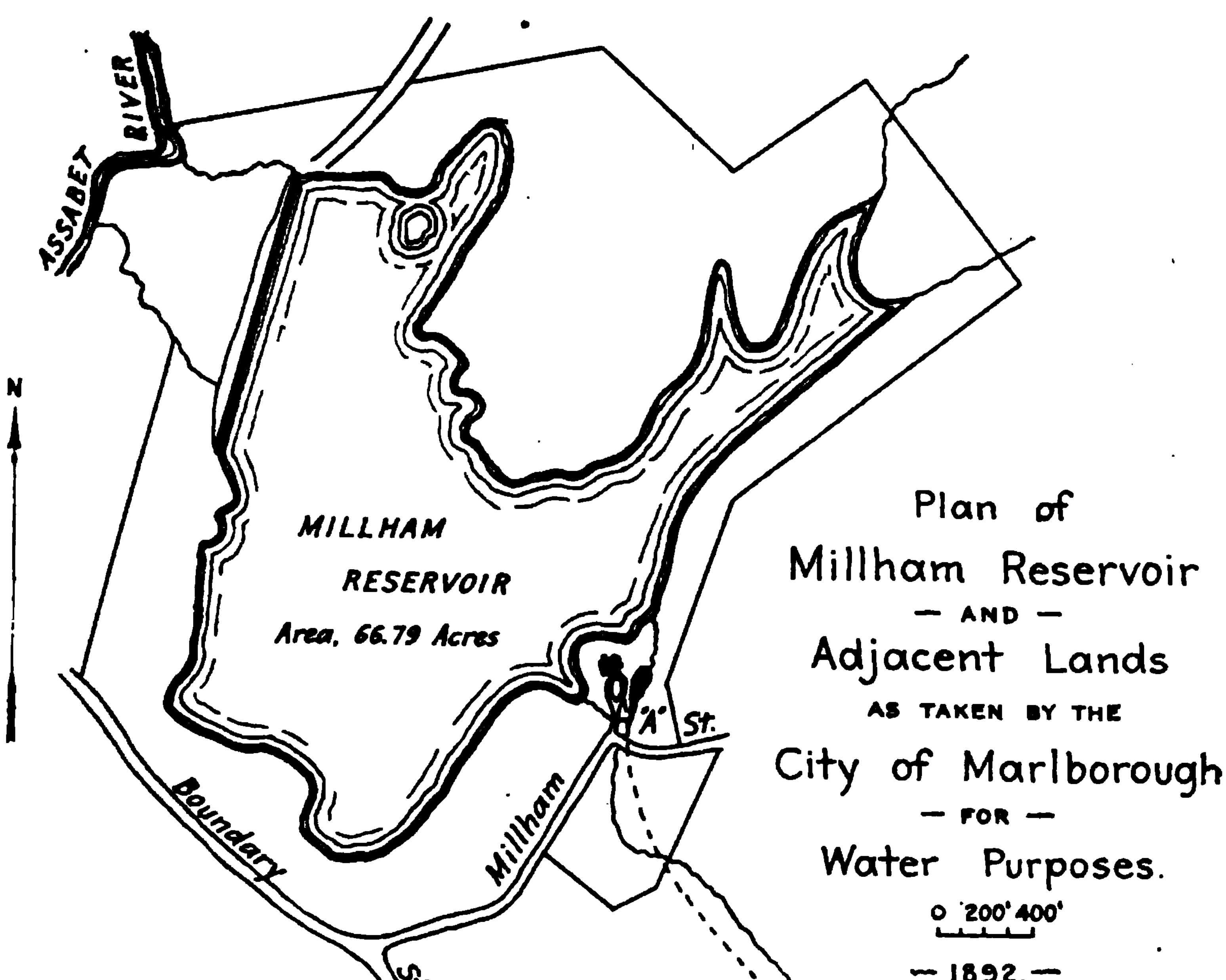


FIG. 2.

one thousand cubic yards of rock, a wasteway was cut through this ledge. Fig. 1, Plate I, is a view of the dam, and Fig. 2, Plate I, shows the wasteway.

A pumping station, called Station No. 2 (see Fig. 1, Plate II), was built on the south shore of this reservoir. In this station is a high-duty Worthington pump of two and one-half million gallons

capacity, and two boilers, sixty inches in diameter and sixteen feet long, built for a working pressure of one hundred and twenty-five pounds. The head against which the pump works when pumping to Sligo Reservoir is 408 feet.

The water of Millham Brook enters the reservoir at the point marked "*A*" on the plan, Fig. 2. Forty or fifty years ago this was the site of a small sawmill such as were common in those days, and part of the small dam only remained. As it was probable that we should be in need of more water than Lake Williams could furnish before the new reservoir was completed, advantage was taken of the situation, the old milldam was rebuilt, and a pipe about fifty feet in length was laid from the small basin thus formed to the gate chamber of the pump well, and we were able to pump a limited amount from this source in the spring of 1893.

The force main from this station is two and one-quarter miles long, passing through private land for one half of the distance, the balance being in Northboro Street and Lakeside Avenue, which passes directly in front of Station No. 1 at Lake Williams.

The force main from the latter station crosses the avenue at this point, and the two mains are connected here by a Y-branch; between this connection and Station No. 1 is a four-way branch, with four gates controlling all the outlets (see plan, Fig. 3).

After crossing the avenue, the original force main passes northeast through private land for about twelve hundred feet, and enters the south end of Sligo Reservoir grounds, passing east through these grounds in a continual line to Broad Street (at this point it becomes the main distributing pipe); then south on Broad Street to Lincoln Street, then east down Lincoln Street. Lincoln Street going west forms a junction with Lakeside Avenue, near Station No. 1, as shown in Fig. 1.

From the east outlet of the four-way branch on the force main in front of this station, a pipe is laid over Lincoln Street to the junction of Lincoln and Broad streets, and connects with the main distributing pipe (see Figs. 1 and 3).

From a Y-branch on the force main in the reservoir grounds a pipe leads to the south end of the reservoir, discharging at high-water level; at the outfall of this pipe is a flight of stone steps for the water to fall over; there is a gate on this line, and one on the main just east of the Y-branch.

About two hundred feet east of this point, the pipe line leading

PLATE I.

FIG. 1.—MILLHAM DAM, LOOKING SOUTH.

FIG. 2.—WASTEWAY, MILLHAM RESERVOIR.

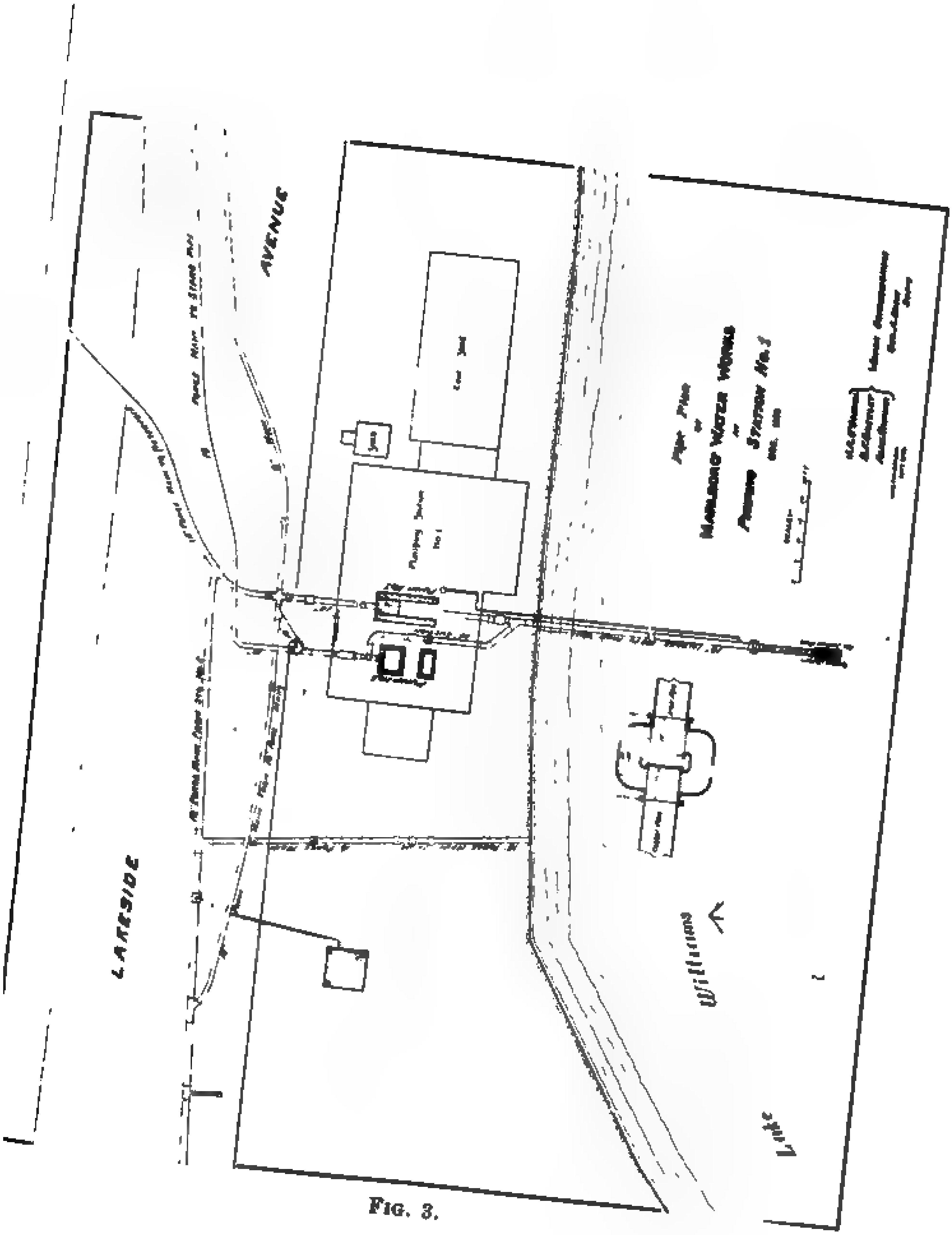


FIG. 3.

from the gatehouse is connected with this main, with a gate on each, set near their junction. The gatehouse is on the north end of the reservoir.

This combination of pipes and gates permits the cutting out of the reservoir for cleaning or repairs, supplying the city by direct pumping through two lines, or either one of them; it also permits the cutting out of the main on Broad Street, between Lincoln Street and the reservoir grounds, and supplying the city from the reservoir by the water passing back through the force main to Station No. 1, then through the pipe line leading from the four-way branch, over Lincoln Street, to the junction of Broad and Lincoln streets.

On the force main from Millham Reservoir, about one hundred feet west of its junction with the old force main at Station No. 1, is a Y-branch, from the outlet of which a pipe connects with the west outlet of the four-way branch on the old force main; this forms a by-pass, by which we can pump directly to the city through the Lincoln Street main from Station No. 2, as well as from Station No. 1.

From the force main of Station No. 2, between the Y-branch and its connection with the old force main, a discharge pipe is laid through the station grounds to Lake Williams.

There is a gate on this pipe, and one on each side of the branch from which it is taken; this pipe is used as a blow-off, and by opening and closing the proper gates, the water in the distributing reservoir can be drawn off into the lake, and at the same time the city can be supplied by direct pumping from either station through the main on Lincoln Street; it is also used when pumping from Millham Reservoir to Lake Williams.

If the water in Lake Williams is at high-water mark in the spring, it will furnish a supply for the season; and to accomplish this the pumps at Station No. 2 are run in the winter and spring (when the water at this place is at its best) until the amount pumped to Lake Williams, together with what it receives from its own watershed, assures this result. Station No. 2 is then put out of commission for the balance of the season, or until such time as an additional supply from this source is needed.

These conditions had an influence on the treatment given to the bottom of Millham Reservoir at the time it was built.

The shores of the reservoir are mostly steep, as shown in the view, Fig. 2, Plate II, and with but little shallow flowage; about

PLATE II.

FIG. 1. — PUMPING STATION NO. 2.

FIG. 2. — MILLHAM RESERVOIR LOOKING SOUTH.

sixty per cent. of the bottom was meadow land, and along the course of the brook that flowed through it, the mud in places is quite deep; the balance of the basin was woodland.

Plans for stripping the whole basin were considered, as well as for covering that part where the mud was deep with sand and gravel taken from the hills that formed a large portion of the south shore of the reservoir.

The estimated cost of stripping the whole basin made by our engineer was from seventy to eighty thousand dollars.

The question of filtration was also considered, and it was thought possible that in the near future the advancement made in the construction and introduction of filters in this country might be such that this money, expended in filtering the water from all sources as it went to the consumer, would yield the greater benefit.

It was then decided for the present to strip only the surface from high-water mark out to a point where the water would be ten feet deep with a full reservoir, and to fill the shallow places with the material thus removed.

Under these conditions, using Lake Williams in part as a storage reservoir, we are able to select the best and most convenient time to pump from Millham Reservoir, and we have up to the present time secured a very satisfactory supply from this source; and the saving in interest has amounted to twenty-five per cent. of the estimated cost of stripping the balance of the basin.

The force main from Station No. 2 is laid to a hydraulic grade to within one-half mile of Station No. 1, where it reaches the summit; from this point to the station, at the point where the blow-off pipe discharges into the lake (Fig. 3), the fall is forty feet.

There is a considerable population along this line where it lies in the highway which is supplied from this force main, and when pumping into Lake Williams sufficient back pressure has to be maintained at the discharge pipe to supply the services on the summit.

At first, to accomplish this, the gate on the discharge pipe was partly closed, but we found that it was difficult to adjust this gate just right every time; and there was another difficulty, if not danger, in this method, for if, when the pumps were stopped, this gate was not immediately closed, the discharging water would cause a strong siphon action on the summit, and possibly draw air in through the service pipes, and cause trouble when the pipes were filled again.

As a secondary means to avoid this, a specially designed automatic gate was tried, but this proved a total failure.

I then designed the siphon now in use, which was constructed by inserting two three-way branches in the discharge pipe, where it passes through the station yard, spaced eight feet on centers, with the outlets on top, and with a gate set between them. Pipes rising two feet above the surface with flanges on top were set in these branches. The siphon is bolted to these flanges, and is constructed of spiral riveted galvanized iron pipe, and is forty feet high, or a little above the grade of the force main at the summit. A view of this siphon is shown in Fig. 1, Plate III.

A vertical check valve, inverted, was placed on the top of the elbow of the discharging leg of the siphon, to act as an air valve.

By closing the valve between the three-way branches, the water flowing to the lake must pass over the siphon, and this affords a free passage for water and a constant head, and the pumps at Station No. 2 can be stopped and started without danger to the pipe line.

When the pumps at Station No. 2 are stopped for the day, the gate near the main, on the discharge pipe, is closed, and the gate on the force main opened, thus connecting this line with the distributing system, of which it is a part at all times when the pumps at Station No. 2 are not running.

In cold weather, to prevent the siphon from freezing, the gate between the two three-way branches is opened, allowing all the water to drain into the lake.

Previous to the introduction of a public water supply, Marlborough had relied upon hand engines and small reservoirs for portection against fire.

After the water works were in operation, the hand engines were put out of commission, and the water for the extinguishment of fires was taken directly from the hydrants.

In 1894 the growth in the number and size of the factories, and other private and public buildings on the higher levels in the west part of the city, was such that the water pressure did not furnish adequate protection for that district, and steps were taken to improve this service.

The first cost, cost of maintenance and efficiency of steam fire engines, and of an independent pipe system supplied by a standpipe, were considered, and it was decided in favor of the standpipe system; and work was immediately begun upon its construction.

PLATE III.

FIG. 1. — PUMPING STATION NO. 1, AND SIPHON.

FIG. 2. — VIEW OF STANDPIPE AND SLIGO RESERVOIR, FROM THE SOUTH SIDE OF LAKE WILLIAMS.

This fire service consists of a standpipe, three miles of fourteen-, twelve-, ten-, and eight-inch pipe, thirty-two hydrants, and a Barr compound condensing pumping engine of about one and one-half million gallons capacity.

The engine was erected in Station No. 1 at Lake Williams.

The standpipe is located on Sligo Hill near the south end of the distributing reservoir; the tank is thirty feet in diameter and thirty-five feet high, with a conical bottom, and has a capacity of two hundred thousand gallons. A view of the standpipe is shown in Fig. 1, Plate IV. It may be seen in the distance in Figs. 1 and 2, Plate III. It is constructed of iron, with the round-about seams single riveted, and the vertical seams double riveted for the first fifteen feet. The conical bottom is made with butt-strap joints, with the butt straps on the inside, double riveted. A flange is turned up on the outer edge of the conical bottom plates, and is double riveted to the bottom sheets of the tank, and also to the steel channel plates that surround the bottom of the tank on the outside. This channel is riveted to the top of a plate girder three feet deep, which is riveted to the heads of ten steel columns seventy-two feet high. A twelve-inch vertical pipe connects the tank with the ground main, and is protected with a double wooden jacket, with six-inch air spaces; the inside jacket is covered with hair felt one inch thick, which is held in place by brass bands.

A balcony surrounds the top of the tank, which is one hundred and ten feet above the ground.

The roof is cone-shaped, and the extreme height is one hundred and forty-six feet; situated on this elevation, it is a very prominent object.

The standpipe was designed by B. R. Felton, then city engineer of Marlborough, with F. C. Coffin as consulting engineer, and was built by Tippett & Wood, Phillipsburg, N. J. It has never cost a cent for repairs, except for the necessary painting, and is absolutely water tight.

It was the second one of this shape erected, and although smaller, was similar in appearance and design to the standpipe that fell at Fairhaven a short time ago.

This service is for fire protection only, and was designed to deliver ten $1\frac{1}{8}$-inch effective fire streams at any point on the system.

At a test made in April, 1894, ten $1\frac{1}{8}$-inch streams were used, the average length of hose to each line being two hundred and fifty feet. A gage, set on one nozzle of a four-way hydrant to which

three of the ten lines were attached, showed a loss of pressure varying from six to seven pounds. The static pressure at this point is eighty pounds, and the streams were thrown higher than the flagstaff on the four-story factory, at which the test was made (see view, Fig. 2, Plate IV).

The power and volume of the streams shown at this test, and at others made on different parts of the system, demonstrated to the citizens who witnessed them that this district had now an ample fire protection, and that it would take at least five steamers such as are used in cities of the size of Marlborough to duplicate this work.

To prevent this system from becoming useless by any possible accident or conditions that would cut off the supply from the standpipe or pumps, a connection was made between the standpipe and reservoir mains, at the reservoir grounds; a check valve was set in this connection, and a gate on each side of it.

Every manufacturing establishment in the city, with two exceptions, is protected by sprinklers.

In the district covered by the standpipe service, the sprinklers are connected to both systems; and to prevent the water flowing from the high to the low service, a check valve, enclosed in a manhole at the sidewalk, is set in the pipe that connects the sprinkler system with the reservoir service.

At first I had some doubt as to these check valves working satisfactorily under all conditions, but up to the present time they have never caused any trouble; they open freely and close tightly.

There being no water drawn from the standpipe except in case of a fire, except that due to leakage or the breaking of a sprinkler head once in a while, it was thought necessary that some method be adopted to prevent it from freezing. For this purpose the force main of the reservoir and that of the standpipe were connected in the basement of Station No. 1 by a one and one-half inch pipe, controlled by a gate valve; the difference in pressure on the two mains is fifty pounds, and upon opening this valve the water flows from the standpipe to the reservoir main and thus keeps up a circulation. When the water in the standpipe is drawn down about three feet, it is pumped up again.

That this was a necessary precaution was shown by a little incident that happened the second winter it was in operation.

One cold Sunday morning I was called up to the station, and the engineer informed me that the night before when he pumped up the

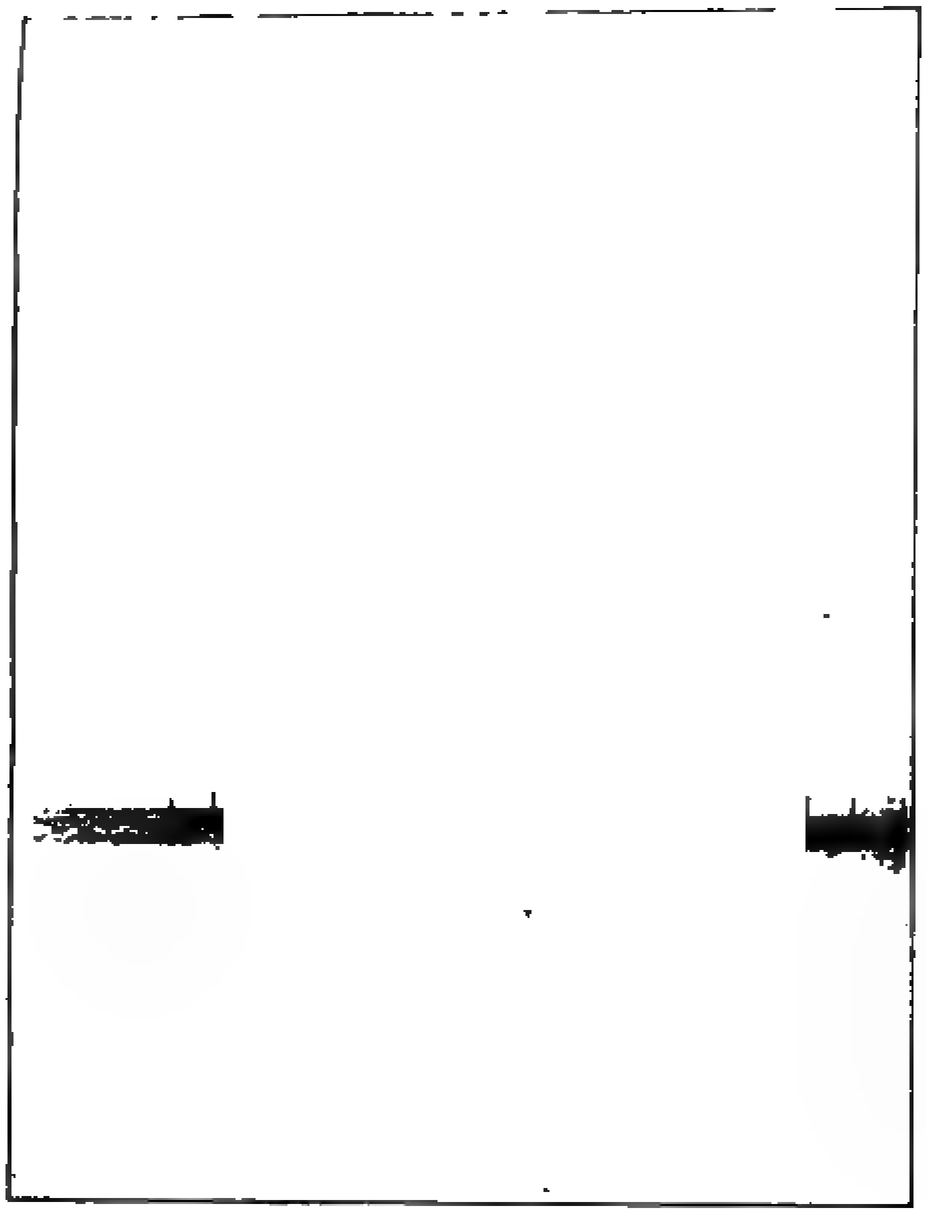


FIG. 1.—SLIGO RESERVOIR AND STANDPIPE.

FIG. 2.—TEST OF FIRE STREAMS FROM STANDPIPE SERVICE.

standpipe he closed the valve on the by-pass (as was usual at that time), and forgot to open it again, and as the gage on the Barr Pump showed only reservoir pressure, he was afraid the standpipe was frozen up. Opening the relief valve and getting no response from the tank proved that this was so.

After carefully considering the matter, I concluded that the first place to freeze would be where the top of the wood jacket butts against the conical bottom, the cone being of small diameter at that point and unprotected, and its shape would be favorable to the removal of any obstruction by pressure applied underneath. Believing that the pipe lines were perfectly safe at two hundred pounds, I decided to try the experiment of forcing the ice up.

Starting up the pumps, I slowly raised the pressure on the force main until the gage showed one hundred and forty-five pounds, after which it slowly dropped back, and the pumps began to speed up, and I then knew that I had broken the ice, or something else. It proved to be the ice; and we have never had any trouble from that cause since.

It is now a standing order that the valve on the by-pass shall never be closed, from the time it opened in the fall until it is closed for good in the spring.

A Winslow recording gage is used to indicate the height of water in the standpipe, and has never failed to work satisfactorily.

The works at this time consist of two storage reservoirs with all their tributaries and water rights, with an aggregate storage capacity of about eight hundred million gallons, and four square miles of tributary watershed; two hundred and twenty-five acres of land from which we removed a number of dwellings, barns, outbuildings, and ice houses — and the city now owns and controls all the land around its reservoirs, and has paid, for land, land damage, and water rights, over one hundred thousand dollars; a distributing reservoir of a capacity of five and one-half million gallons, and a standpipe holding two hundred thousand gallons, both of these situated in Reservoir Park, on Sligo Hill.

The view from this place is unsurpassed in this section, the land sloping away in all directions to the surrounding valleys, in which are located a number of towns.

To the naked eye, the view extends from Mount Monadnock, in New Hampshire, on the north, to the Blue Hills of Milton on the south; from Bunker Hill Monument on the east, to Rutland, called

the center of the state, on the west; and, with a telescope, forty-five towns and villages, and a number of reservoirs and standpipes, can be seen.

The works also include Pumping Station No. 1, which contains two eighty horse-power boilers, one two-million Blake, and one one and one-half million Barr compound condensing pumping engine; Station No. 2, with two eighty horse-power boilers, and a two and one-half million Worthington high-duty pumping engine; 37 miles of distributing pipe; 344 hydrants, with a pressure of from 30 to 142 pounds; 386 gates; 1 200 meters, and 2 250 services.

The net cost of construction has been $586 645, and the net debt is $372 251.

The original works were designed by and constructed under the late M. M. Tidd, C. E., and the Millham supply and standpipe system by B. R. Felton, then city engineer of Marlborough.

During the nearly nineteen years of operation, the works have met every demand made upon them in a most satisfactory manner, and have proved an excellent example of water-works construction as produced by the engineers of to-day.

THE DECISION IN THE DAYTON ELECTROLYSIS SUIT.

[*Reprinted from "Engineering News" of April 17, 1902.*]

A partial victory has been won by the city of Dayton, Ohio, in its electrolysis suit against the City Railway Company. Mr. O. B. Brown, judge of the Court of Common Pleas of Montgomery County, has refused to order the street railway company to install the double-trolley system, as urged by the city, but says the company has been negligent in the operation of its road and must conform to the best standard practice of operating single-trolley lines.

The trial was a lengthy one, the experts were numerous, and there were many exhibits and several experiments before the court. The decision of Judge Brown occupies two full pages of the Dayton *Herald* for April 5, 1902. A large part of the opinion deals with purely local questions, and the findings of the court hinge largely upon the nature of the franchise granted by the city to the street railway company. The decision, therefore, has only a general bearing upon the electrolysis question in other cities, and, it is to be remembered, is subject to review in the higher courts.

After a detailed review of the contentions of the city and the company, and of the law on the subject, the judge concludes that a contract existed between the city and company "for the construction, operation, and maintenance of a single-trolley electric railroad."

Another point made by the judge was that the city had never attempted to compel a change in the method of traction by the exercise of its police powers, and that the court had no authority to exercise such power. For this and other reasons the judge held that even if the facts showed that the double-trolley or the underground conduit system was the only method of preventing the destruction of the water mains by electrolysis, yet the law would not permit him to order the adoption of one or the other mode of traction.

The first trolley line in Dayton was installed in August, 1888, "but the present system of operation did not become general until the early nineties." The first line, it appears, was owned by a company other than the defendant in this suit, and the first noted instance of electrolysis was upon a lead service-pipe, near this same early line,

found in 1893. That same year, Mr. Charles E. Rowe, secretary of the Dayton water-works, was sent to the Milwaukee meeting of the American Water-Works Association, where, the judge says, "The question of the electrolysis of water pipes was first publicly discussed."

Both sides to the suit admitted that the water pipes of Dayton are being damaged by electrolysis, but they did not agree as to the extent of the damage. During the trial a six-inch water main broke, when, in the course of a fire, the pressure was raised from sixty to one hundred pounds. The broken pipe was, the judge says, —

brought into court the following morning and examined by the experts for the first time in court. This showed that the pipe had been badly eaten away throughout its entire length by electrolysis; and indicated to the experts that the current was pretty uniformly distributed over the surface.

Rivers, canals, steam railways, and intersecting street railway lines, the judge says, conspire to make the return of the electric current to the power house unusually difficult in Dayton.

All the experts in the case testified that the defendant had operated its railway "in a very inefficient and negligent manner, and far below the present standard of the art." The bonding is very inadequate throughout. In fact, a chart introduced by the defendant raises "a doubt as to there being any good bonds on most of the system." The experts also agreed that the system of return feeders in use "is not sufficient for the economical and safe operation of the" railway. The ground plates in use are no longer considered good engineering.

The balance of the opinion, with the summary of findings, is given substantially in full, as follows: —

The testimony in this case shows that the plaintiff is powerless to adopt any method whatever to protect its piping system. On the other hand, a single-trolley street railroad, such as the defendant operates, can adopt no method by which the tendency of the current to flow through the earth and on to the pipes can be entirely overcome. But I am of the opinion that by coöperation between the two, such a system could be adopted as would reduce the injury resulting from electrolysis to a minimum or negligible quantity, as the experts term it.

The defendant claims, however, that no system would prove effective as long as the other roads continue to operate as they are, but the testimony shows that any preventive measure adopted by this company would reduce the liability to injury to that extent.

The rails should all be metallically connected by adequate bonding, and the bonding well inspected frequently, and heavy copper cables should be used to conduct the current across the bridges and under the steam railroad crossings and intersecting railroad tracks. Return feeders of sufficient conductivity should connect the rails at various points to the negative bus-bar of the dynamo. This would increase the conductivity of the rail path and induce a much greater quantity of the current to flow thereon.

The ground plates which are still in use by the defendant should be removed, thus reducing the tendency of the current to flow to the underground metallic structures.

Having corrected the system by proper bonding, and by proper rail return, there should be coöperation on the part of the water-works board in permitting to be placed, as may be determined, at the proper places, the necessary insulators in the piping system. A few or none may be required.

A system operated along these lines, without insulators or pipe connections to the rails or dynamo, has proven successful in Hartford, Conn., and in other cities where the conditions are somewhat similar to those existing in this city.

The officials of the city of Chicago have also acted upon this theory, and have passed an ordinance making it unlawful for "any person, firm, or corporation, owning, operating, or controlling any surface or elevated railroad or any street railway within the city of Chicago, upon which cars are now or hereafter operated, by electricity as a motive power, with a grounded return circuit for conveying electricity," to operate their system without a "metallic return circuit of such cross-section and conductivity for conveying the current so used as a motive power, that the maximum difference of potential will not at any time exceed one volt between any part of such metallic return circuit and any water pipes, gas pipes, or other metals not installed for the purpose of forming a part of such metallic return circuit, and that there will not be a variation in difference of potential exceeding one-half volt, between any two measurements made at the same time at points along and upon said metallic return circuit, within a distance of three hundred feet or less from each other."

Similar regulations have been made in other cities in this country, and general regulations have been adopted by the different British boards of trade and by what is known as the Bristol Tramways Act, and it is now generally considered by practical and scientific men that if a difference of potential not higher than about one and one-half volts is maintained in the positive district, and difference of potential not higher than about four volts in the negative district, the pipes will be practically immune from damage.

I am satisfied, from a careful consideration of all the testimony, that if these remedies are applied with intelligence, according to the present state of the art, it is possible to establish and maintain, by careful and frequent inspections and electrical measurements, such a return for the current of the City Railway Company as will practically protect the water pipes of the city, and be also a great saving to the railway company in the cost of operation.

SUMMARY OF FINDINGS.

Upon consideration of the entire matter, I have come to the following summary of conclusions as to the law and facts: —

This court has no authority in law to compel a change in the system from the single trolley to the double trolley, and, if the same was warranted by the law, the facts would not justify such a change.

The defendant has been and is operating its road in a negligent manner, causing continual damage to the water pipes of the plaintiff, for which the plaintiff has no adequate remedy at law, and cannot by any practical method prevent such damage.

It is no excuse in law, and the facts would not justify the defense that other electric lines in Dayton are contributing to this or doing like damage. (Spelling, Sects. 390–397. McClung *v.* North Bend Coke Co., 9 C. C. 259; Meigs *v.* Lister, 23 N. J. Eq. 199.)

It is therefore the duty of the court to enjoin the defendant from so operating its railway, and to compel it, within a reasonable time, to introduce such improvements in the system, in order that the operation of the single-trolley system authorized by the franchise and contract will be in accordance with the present standard of the art of operating single-trolley roads. The plaintiff shall coöperate to that end.

All matters of detail can be arranged between counsel and the court in the final order.

The costs will be adjudged against the defendant.

After the foregoing decision was rendered, counsel for the railway company addressed some remarks to the court, in which it was virtually stated that if the city would let the case stand, without appeal, it would do the same, and, of course, would also comply with the orders just given.

EDITORIAL DISCUSSION IN "ENGINEERING NEWS."

The decision in the Dayton electrolysis suit, reviewed at some length above, while in some respects disappointing to the water and gas fraternities, is nevertheless a signal victory for both the city of Dayton and municipalities at large. The decision recognizes, (1) that trolley currents improperly returned to the power house destroy water mains; and (2) that even when a street railway company has a contract with a city for a single overhead trolley system it must use every well-recognized means to keep its currents off the water and gas mains. The city fought hard to secure an order for a change from the single to the double overhead trolley system, or else to the underground conduit system. This, we think, was a mistake. We have always maintained that it is not the duty of a city to say how elec-

trolysis shall be prevented. The burden should rest wholly with the street railway companies. When a city attempts to say how the problem shall be solved, it assumes more or less responsibility for the success or failure of the remedy. It may even find to its sorrow that it has enteréd into a contract, and has thus debarred itself from otherwise possible relief. In the Dayton decision, the judge virtually declares that no matter how dangerous the menace from electrolysis, nor how effective a remedy might be found in the double overhead trolley system, the city cannot force the adoption of the latter because it has entered into a contract for the single overhead trolley. In the future, cities will do well to see that their street railway franchises do not cut them off from relief from damages to their own property. In addition, no street railway franchise should be granted hereafter which does not specifically provide that the system shall be so constructed and operated as to return the current to the power house without menace to underground furniture and without any other danger to life or property.

INVESTIGATIONS IN REGARD TO COLORING MATTER IN WATER AND METHODS OF REMOVAL.

[*Discussion, March 12, 1902.*]

President Merrill. The first paper announced upon the program for the afternoon is by H. W. Clark, chemist, Massachusetts State Board of Health, on "Investigations in Regard to Coloring Matter in Water and Methods of Removal." I am sorry to tell you that a telegram has just been received from Mr. Clark announcing that he is too ill to be present with us to-day. We are very fortunate in having here, however, one of our members who is familiar with this subject, and it gives me great pleasure to call upon Mr. Desmond FitzGerald at this time.

Mr. Desmond FitzGerald. Mr. President and fellow-members: I think it is little short of torture to be brought back at a second's notice from the old "Suwanee River" — where, under the spell of the sweet voices of our quartet, I was paddling down the stream in a canoe, thinking of the "old folks at home" who were waiting to welcome me to the cabin — and be asked to address a public assembly. [*Laughter.*] And yet I think I ought to thank our President for not having given me notice before the dinner began that I was to be called on, for, while in blissful ignorance of what was to follow, I have been able really to enjoy myself up to the present moment. The fact is, I always do enjoy these dinners of the New England Water Works Association very much, and I regret that it is not possible for me to be here oftener. As I look around the tables I notice some changes and a number of new faces. The most surprising change is in the head covering of some of our members, which seems to have become of a purer *color* as time has gone by, — partly accounted for, perhaps, by the fact that it is twenty years ago that the New England Water Works Association was organized.

While, as I have said, I am always glad to be here with you, I have sometimes thought I would never come to one of these public dinners again, because it always seems to fall to my lot to fill some gap. I know we all anticipated the pleasure of listening to Mr. Clark's paper, and it is a disappointment that we are not to hear it.

As I look around I see others here who could take Mr. Clark's place much better than I can, Mr. President. However, I presume something is expected of me now, and perhaps it may be of interest if I briefly review some of the history of this subject.

I remember very well that when the whole of Boston's supply came from Lake Cochituate there were no complaints about the color of the water. The color of the Cochituate water was about .25 to .30 on the Nessler scale. There were a good many complaints about the water in those days, however. Sometimes people could not brush their teeth with it, but that was n't a very serious thing, — they could get along without that, perhaps; sometimes they did n't want to bathe in it, and sometimes they certainly did n't want to drink it — but the color was all right. When the Sudbury River water was introduced for the first time, in 1872 or 1873, the works being completed from 1875 to 1878, that water was highly colored. I may remark, by the by, that the only reason why the Cochituate water was a light colored water was because it came from a lake so large in proportion to its watershed that the water became decolorized, or largely decolorized, by storage. We all know about that now, but we did n't seem to know so much about it in those days.

For a number of years we have been taking the colors of the waters in the brooks which feed the lake, and we know that the average color is something over 1.00 on the Nessler scale. That is reduced by storage to about .30. Then the Sudbury water came in from three small basins, in the first place, with a drainage area of about seventy-eight square miles, and that water was up to .70 and even higher, while the average color of the water running in the river was perhaps 1.00, as I remember it, about the same as that running in the brooks feeding Lake Cochituate. But of course we had to supply that water to the city at a very much higher color than the Cochituate, and people complained of it.

Now, I lay a great deal of stress on this matter of getting rid of the color in water, and it seems surprising to me to listen to the opinions of some people on this question of pure water, good water, that you are not ashamed to pour into a glass. For instance, look at the situation in Brockton to-day. There is a splendid great city, with intelligent men in it [*laughter*], and yet to-day they stick at the point of getting a first-class water, with almost no color, because it is going to cost a little more than a highly colored water. And there is that same fight right along that line almost everywhere.

Brockton can get the water of Silver Lake, which is a perfectly splendid supply, and you would think they would jump at it.

One step has led to another in the investigation of this subject, and we have made a careful study of it because it was so important in the city of Boston. I think I had the honor of conducting almost the first observations on an extended scale that were made in this line. The color of the water in the basins, brooks, and swamps on the Sudbury watershed was taken at many points every week for many months, and tabulated. We found that the water as it comes from the hills, before going into the swamps at all, has very commonly a color of .20 or .25 before it is brought in long contact with vegetation. We found that the water flowing from some of the hills surrounding Cedar Swamp, for instance, had a color of .25 and that after being held in the swamp, it would run up to 3.00 or 4.00. That led to the conclusion that the great cause of the high color in the Sudbury water was its being held in the swamps. Some of it comes from iron, but I think that for our purposes here to-day we may practically ignore the question of iron as giving color to the water. That part of the subject has been considered in great detail in some of the Boston Water Works reports, and owing to its complications need not be referred to here. It may be stated as a general rule that New England waters get their color from swamps.

Our investigations led us to the adoption of a scheme for draining the swamps, which was formulated in a report I made to Mr. Stearns and contained in the State Board of Health report on a Metropolitan Water Supply, 1895. It is rather interesting because it was something new in those days. The question to be solved was, What will be the effect on the color of the water if the swamps are partially drained? My estimate was that, by carrying out a certain system of draining and interception, the water would be reduced forty-two per cent. in color.

That system has been carried out on the Metropolitan Water Supply. I don't know exactly what the result has been on that part of the works which Mr. Richardson has charge of, but, on the part that I have particular charge of, the color has been reduced just about forty-two per cent., as far as I am able to say now.

Now, by filtration in the ordinary way in open filter beds, by the slow process of sand filtration, I have found by experiments during three years at the Chestnut Hill Reservoir, that, on the average, you can practically reduce the color of the water about twenty-five

per cent. I am not going to say anything about the chemical side of the question, because there are others here who can speak of that much better than I can. Now, it seems to me, Mr. President, considering that a gentleman is here with an admirable paper, which you are all anxious to hear, that I have said enough. If there are any questions that any one would like to ask, I would be happy to try to answer them, and perhaps some one would like to take up the matter and carry it along further.

I will say one word more on the question of storage. In this very arge reservoir at Clinton, which Mr. Stearns is building, I suppose the color of the water will be reduced to such an extent that it will practically not be noticed at all, because the water will be held in a large lake for about a year, and in that time almost complete decolorization is expected to take place. It has always been a delight to me to go to some large lake, like Lake Winnepesaukee, and see how absolutely pure in color the water is. But, if you walk around the shores of the lake, you will find the streams entering the lake are often very highly colored. The removal of this color is of course due to long storage, and that is what we are trying to do in building such large reservoirs, — to hold the water and store it long enough to get rid of the color as far as possible.

But it is not always practicable in small works. The resources for doing so are not always available, and I have sometimes thought that a good deal could be accomplished on some of these smaller works by turning some of the feeders on to large areas of gravel. I have seen situations where the erection of a small diverting dam would turn the water on to gravelly areas, through which it could percolate to the water tables below and then flow into the stream again, a very much whiter and purer water. I only throw that out as a suggestion. There are other ways. There are ways of turning a brook on to small areas of gravel and then sinking pipes and taking the water out from below. But I see I am getting into a very wide field, and so, thanking you, gentlemen, for your attention, and assuring you of my pleasure at being here with you again, I will give place to some one else. [*Applause.*]

THE PRESIDENT. This is an interesting subject, gentlemen, and I trust it will bring out a full discussion. Mr. FitzGerald has referred in a word to the chemical side of the question. There is a gentleman present this afternoon who can perhaps give us some information from that standpoint, and I will ask Mr. R. S. Weston if

he will speak on the chemical side of the removal of color from water.

MR. R. S. WESTON. Mr. President, and members of the Association: This is the first meeting of the New England Water Works Association that I have attended for a year and a half, and I almost think that I am entitled to be allowed to enjoy it without interruption.

I have done a little work on the treatment of color in water, largely laboratory work, this last year in New Orleans. As you know, the Mississippi River comes down from the country above, bringing large quantities of silt and a large amount of vegetable matter, trunks of cypress and other varieties of trees. In the course of ages the whole delta on which New Orleans is situated has been built up in this way. If one bores a well about one thousand feet deep or less at New Orleans, one obtains water which has a color of from three hundred or four hundred to eight hundred or nine hundred parts per million. This water is quite alkaline. The treatment and removal of the color in it is something which is very difficult.

In the consideration of the question, namely, which would be the best source of water supply for the city of New Orleans, it was necessary, in order to satisfy certain elements of the population, to consider the question of an artesian well supply, and, in connection with that, one had to consider, more or less, the problem of the removal of this color from the well water. It was found that the only way to treat this highly colored water which is possible at the present time is to add sulphate of aluminum, allow the water to coagulate for some time, and then remove the cogulated masses by filtration. The ordinary colored water of New England — soft water — can be treated with about two to two and a half grains of coagulant to each gallon of water, for every one hundred parts per million of color to be removed. But in New Orleans we find that this ratio has to be multiplied several times in order to obtain the same result. The removal of color from water which is very alkaline, that is, which contains lime salts or sodium carbonate, is a matter of considerable difficulty. It is also found that if one neutralizes the alkali in the water before one adds the coagulant, a very much smaller amount of coagulant is necessary to treat the color. About the same amount of coagulant is required to remove the color of this water which has been neutralized as is required to treat waters in New England which need not be neutralized.

The following results of experiments made at New Orleans may be of interest: —

RESULTS OF EXPERIMENTS UPON THE DECOLORIZATION OF HIGHLY COLORED WATERS FROM DEEP WELLS AT NEW ORLEANS.

Sample.	Parts per Million.		Grains per Gallon of Sulphate of Alumina.		
			To Decolorize		To Effect a Beginning in Color Removal from Original Water.
	Alkalinity.	Color by Platinum Standard.	Original Water.	Water after Neutralization.	
A	412	190	13	3.0	10
B	365	200	5	0.5	3
C	420	120	7	1.2	5
D	403	350	7	2.5	5
E	441	180	18	3.0	6

I think this subject of color removal is a very interesting one, and one which really ought to be studied in an experimental way somewhere and for some time. We have data now from all over the country with reference to suspended matter in streams, which are sufficient in almost all cases to enable an engineer to design a filtration plant which will meet the local conditions without much chance of failure. But the data necessary to design a plant which will remove color under all conditions successfully are not yet at hand.

One very peculiar thing about the color of the water, of the Southwest especially, is the way it is removed from solution by contact with suspended matter. I don't know of any other way to express it. For example, the water of the Yazoo Valley, and the water of all those small streams which empty into the Mississippi from Cairo down to New Orleans, is highly colored. It is more highly colored, perhaps, than that of any of our New England swamp waters, the flat nature of the country allowing a longer contact between the water and the organic matter contained in the swamps. When the water emerges from these rivers it is very highly colored, but in a short time after it has mixed with the Mississippi, along with the large amount of silt which is borne down from above, its color disappears entirely. The color is absorbed by the silt, and

the organic matter, which is found by analysis to be present in a dissolved state in the tributaries, is found in a suspended state in the water of the main river itself. The color of the Mississippi water, after the suspended matter is removed, is practically zero, while the color of these tributaries is as high as eight hundred or nine hundred units.

There is a misconception, I find, all over the country, with regard to the meaning of the terms "color" and "turbidity." I think it is best to consider the color as that which is not readily removed by straining. The vegetable stain or color is what produces the tea-like appearance of water, while the turbidity is that which offers resistance to the passage of light, — that is, suspended matter. Mr. Hazen and Mr. Whipple, as you all know, have been lately doing some work for the United States Geological Survey, and have devised two very convenient, portable, and simple pieces of apparatus for determining color and turbidity. I will not attempt to describe these pieces of apparatus, for they will be described very soon in a bulletin of the Hydrographic Department of the Geographical Survey.* It is to be hoped that every superintendent of water works will get these pieces of apparatus and make observations of color and turbidity for the common good.

THE PRESIDENT. I will call upon Mr. C.-E. A. Winslow.

MR. C.-E. A. WINSLOW. I do not believe I can add anything to what has been said. I have been very much interested in what Mr. FitzGerald has reported about removing color by filtration through sand. From his results it would appear that the importance of that method of color removal has been underestimated. Considerable attention has been paid to the effects of storage and sunlight, but data with regard to the effect of filtration on highly colored waters are not abundant. The Lawrence filter, which effected a reduction of only 15.4 per cent. in 1893, falling pretty steadily to 8.3 per cent. in 1899, does not furnish a general precedent because the initial color of the water is so low. I hope that, somewhere, more experimentation will be done along this line and additional observations published.

THE PRESIDENT. The subject is now open for general discussion.

MR. F. N. CONNET. It is possible that Mr. Weston refers to the apparatus I am about to describe, and it has so many good features that it is well worth our attention. It consists of two aluminum

* Circular No. 3, Division of Hydrography, U. S. Geological Survey. — EDITOR.

tubes, each two hundred millimeters long, and fitted at each end with caps of clear glass. One tube is filled with the water whose color is to be tested, and the other is filled with distilled water. The latter tube has a little spring clip at one end for holding a disc of slightly colored glass. A number of colored glasses of various thicknesses is provided, and it only remains to select the proper thickness so that when the observer looks through both tubes simultaneously, the color will be the same. The glass discs are all numbered to correspond with standard platinum solutions.

When the water to be tested is highly colored, it is observed through a tube only one hundred millimeters long, and when it is still more highly colored it is observed through a 50-millimeter tube. Extremely high-colored water should be diluted a known amount before testing.

This device affords a convenient, portable, and unchangeable method of measurement, and there is no possible error as to the color of the standard, as there sometimes is when the solutions are made up with platinum salts from different manufacturers.

This device was perfected by Mr. Allen Hazen, of New York City, and I think he designed it originally for the United States Geological Survey.

PROCEEDINGS.

March Meeting.

Young's Hotel,
Boston, March 12, 1902.

President Frank E. Merrill in the chair.

The following members and guests were in attendance: —

Members.

L. M. Bancroft, E. C. Brooks, G. A. P. Bucknam, George Cassell, G. F. Chace, E. J. Chadbourne, J. C. Chase, J. W. Crawford, A. O. Doane, H. P. Eddy, J. N. Ferguson, Desmond FitzGerald, W. E. Foss, F. L. Fuller, Albert S. Glover, F. W. Gow, F. E. Hall, J. O. Hall, J. C. Hammond, Jr., H. G. Holden, J. L. Howard, J. William Kay, E. W. Kent, Willard Kent, C. F. Knowlton, A. E. Martin, W. E. Maybury, Frank E. Merrill, L. Metcalf, H. A. Miller, F. L. Northrop, J. B. Putnam, W. W. Robertson, G. M. Saville, E. M. Shedd, C. W. Sherman, H. O. Smith, J. Waldo Smith, G. A. Stacy, J. T. Stevens, H. L. Thomas, R. J. Thomas, W. H. Thomas, D. N. Tower, G. W. Travis, W. H. Vaughn, C. K. Walker, R. S. Weston, C.-E. A. Winslow, G. E. Winslow, E. T. Wiswall.

Associates.

Builders' Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; M. J. Drummond, by Lester E. Wood; Hersey Mfg. Co., by Albert S. Glover; Henry F. Jenks; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by S. F. Ferguson; National Meter Co., by J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Norwood Engineering Co., by W. N. Hosford; Perrin, Seamans & Co., by James C. Campbell and Charles E. Godfrey; A. P. Smith Mfg. Co., by W. H. Van Winkle; Union Water Meter Co., by F. L. Northrop and C. L. Brown; United States Cast Iron Pipe and Foundry Co., by John M. Holmes.

Guests.

Nelson E. Bryant, Shanghai, China; W. H. Greenwood, Boston, Mass.; C. B. Russell, S. E. Jackson, A. F. Hall, George P. Hall, L. M. Hudson, Marlboro, Mass.; J. F. Gleason, Quincy, Mass.

The Secretary read the following names of applicants for membership, the applications having been approved by the Executive Committee: —

For Resident Member.

J. S. Chase, Hartford, Conn., Secretary Hartford Water Board; Samuel P. Senior, Bridgeport, Conn., Engineer and Superintendent Bridgeport Hydraulic Co.; William H. Hart, Bridgeport, Conn., Assistant Engineer, Bridgeport Hydraulic Co.

For Non-Resident Member.

William G. Raymond, Troy, N. Y., Consulting Engineer on new supply works, Troy, N. Y.; Carleton E. Davis, Upper Montclair, N. J., Engineer in charge of construction of new storage reservoir, Newark, N. J.

On motion of Mr. Fuller, the Secretary was directed to cast the ballot of the Association in favor of the applicants, which he did, and they were declared duly elected members of the Association.

The first item upon the program was a paper by H. W. Clark, Chemist of the Massachusetts State Board of Health, on "Investigations in Regard to Coloring Matter in Water and Methods of Removal." President Merrill announced with regret the receipt of a telegram from Mr. Clark announcing his inability to be present on account of illness, and called upon Mr. Desmond FitzGerald to address the meeting upon the subject-matter of Mr. Clark's paper. Mr. FitzGerald responded with an interesting contribution, and he was followed by Mr. R. S. Weston, — who spoke particularly of certain recent work in New Orleans, — Mr. C.-E. A. Winslow, and Mr. F.N. Connet, who described a portable device for color testing.

Mr. Caleb Mills Saville, Division Engineer, gave a description, illustrated by the stereopticon, of the work of the Metropolitan Water and Sewerage Board in the construction of reservoir and standpipe at Forbes Hill, Quincy, Mass.

The Committee on Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto was not ready to report, but a certain amount of progress was reported, and it appeared that the Committee is going into the matter with a good deal of thoroughness.

Adjourned.

MEETING OF THE EXECUTIVE COMMITTEE.

715 TREMONT TEMPLE,
April 17, 1902.

The Executive Committee met at 10 A.M., President F. E. Merrill in the chair, and present, also, Messrs. L. M. Bancroft, C. W. Sherman, W. B. Sherman, H. O. Smith, R. J. Thomas, and Willard Kent, Secretary.

On motion of Mr. Thomas it was voted: That the President and Secretary be empowered to renew the lease from the Boston Society of Civil Engineers of the rooms in Tremont Temple, on terms at least as favorable as those of the present lease.

The choice of a place for the Annual Convention was the next business. The Secretary reported the result of the expression of opinion from members, as shown by the return postal cards, as follows: —

	Members.	*Associates.*	*Total.*
Boston,	110	15	125
Atlantic City,	84	6	90
Montreal,	70	14	84

After discussion, the Executive Committee voted unanimously in favor of holding the Convention at Boston.

It was voted: That the President, Secretary, Treasurer, and Advertising Agent, with Mr. Harold L. Bond (Associate), be a committee with full powers to make all arrangements for the Convention.

Adjourned.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVI. September, 1902. No. 3.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

HOW TO OBTAIN THE BEST RESULTS IN SMALL PUMPING STATIONS.

BY HARRY F. GIBBS, ENGINEER WATER WORKS PUMPING STATION, NATICK, MASS.

[*Presented February 12, 1902.*]

Mr. President and Gentlemen, — As you are all aware, there have been read before this Association a number of interesting papers on high-duty pumping engines, giving descriptions of the same, their cost, the duty obtained, etc. In New England every town of any size has its public water supply, and in a majority of cases the pumping engines are of the tandem compound condensing type, there being, so far as I know, but two water works supplying less than ten thousand inhabitants which have the fly-wheel type of pumping engine, — Abington-Rockland, and Andover, Mass.

We who are doomed to run the old type of engines that were the standard twenty years ago, — while we believe that the pumping engine of the future will be of some high-duty type, whatever the size of the town may be, and while we look with longing eyes at the nicely running fly-wheel engines in use in our cities, — in most cases can never enter the promised land. And, as we cannot alter present circumstances, let us see how we can make the best of existing conditions.

As there are many cases where superintendents are also engineers of their pumping plants, and in most such cases the plant has to be neglected more or less that they may give office and line work the necessary attention, I am constrained to prepare this paper, hoping it may prove useful in such cases. Also, where superintendents are

not obliged to handle the coal shovel, but are interested to know whether their pumping plants are giving the best results, I trust they may find in this paper some information that will help them in their conclusions.

Now, as the vital principle of the plant is contained in the boilers, let us begin there. We will assume that the boilers are of the horizontal return tubular type, of course proportioned to the work the engine has to do.

It has always been the custom, as far as I have observed, to proportion the grate surface according to the diameter of the boiler; that is to say, a boiler five feet in diameter will have a grate surface of twenty-five square feet. Whether the boiler is driven or not, I have always found these proportions too large, and in every case where I have reduced grate surface by bricking up the fire box on the sides, the duty of the pumps has been increased, and the temperature of the chimney gases decreased, as shown by the decreased temperature of the boiler room.

My smoke bonnet is painted with a paint mixed with oil, and it is not blistered and does not peel at all. The paint has been on about a year. My theory is that with a slow fire the gases are apt to ignite in the uptake instead of in the tubes.

In bricking up furnaces, care must be taken to fill in solidly behind the wall, so that no space shall be left through which air may be drawn up.

Next, are there any cracks in setting, iron fronts, on top, or in any fittings between uptake or chimney that will allow air to leak through? Test by taking a torch, with dampers open, and holding it near any such crack: if flame is drawn in, mark the place with chalk. Stop the cracks in brickwork with calcined plaster, using a putty knife. (Don't mix much plaster at a time, as it sets very quickly.) If there are air leaks on top of boiler where brickwork is built in against it, or over the back connection, lay down asbestos paper and cover it with fine sand. Calk spaces in ironwork with asbestos wicking and cover with putty. Be sure that brickwork over fire doors is tight, that the gases may not take a short cut to the chimney. You will be surprised at the results, if you had many cracks in the setting.

I will not touch on keeping boiler tubes clean, for of course you all do that.

Lack of air space in grates is a very bad disease. I have been in

the habit of splitting my grates and spacing them farther apart as a cure for this trouble. Now, that allows quite a lot of coke to fall through the grates. Well, on the last hour of my run I wet the contents of the ash pits and throw them into the furnaces, and from the refuse of a ton of coal I get fuel enough to run an hour. I have done this for twenty-one years, — and that means millions of gallons of water pumped with a waste product. Always keep ash-pit doors wide open; if you have a fireman and you find him closing the doors to check the fires, take them off all together. When fires are to be checked do it with the damper in the uptake or chimney; for checking at ash-pit doors is like trying to stop a runaway horse by dropping the reins, and putting brakes on the wheels. Put the bit in his mouth; or, in other words, use damper in chimney. You must get about twenty tons of air through your fires for every ton of coal you burn, and this will not be possible if ash-pit doors are closed. Also, the grate bars will last a great many years longer if they are kept comparatively cool.

Now as to feed water; the ordinary compound condensing pumping engine will give you a hot well temperature of about 100° F. Pumping from the hot well through heater will raise this temperature to 120° F. Now, if you will disconnect the exhaust of your air pump from the main heater, and have that exhaust go through another small heater (of course taking feed water through the same), this will bring the temperature of the feed water up to about 170° F. In plants that have no jacket pump a large amount of heat is being blown to waste through traps. I made some experiments with the steam loop, for the return of this water to the boilers; but having trouble in getting the loop high enough, I have adopted a device which pumps the jacket water into the feed pipe with the feed water increasing the temperature to such a point that the business end of a parlor match held against the pipe will melt and ignite. I don't know how hot the feed water is now, as my thermometer, which was graded up to 200°, blew up when it was immersed in the water. The water when drawn from the feed pipe has little jets of steam in it. The jacket condensation is a gallon every three minutes with a temperature of 315° F. In *Steam Engineering* of May, 1901, is a cut and description of the device, to which any one interested is referred. The cut is here reproduced as Fig. 1.

Feed steadily and from main pumps if possible, and thus save the steam, oil, and packing that it would take to run a feed pump.

If you have a damper regulator that won't keep the steam within a pound of a certain point, there must be something the matter with it, at least if it is of the more modern types. Causes for its not

FIG. 1. — JACKET PUMP.

working promptly may be, — the lever arm may touch somewhere, pressure pipe may be stopped up, or, if it is a water piston regulator, the valve may be either stuck or leaking.

As to the pumping engine itself, one thing of importance is to reduce engine friction as much as possible. One step in this direction is to have the piston rods packed in such a way as to reduce friction there as much as possible. A very good way is as follows: Take any round rubber-cored packing that is an easy fit for the stuffing box; cut rings as long as you can crowd into the box; put in a ring of packing, then take asbestos wicking and wind around rod twice and tie it once, then put in another ring of packing, and then more wicking, alternating until stuffing box is full; screw up the stuffing box hard and let it remain so until just before starting up, then slacken off the nuts as far as you can safely, and the steam and water getting in among the packing after a few minutes will pack the rod nicely. You will find that this way of packing will cause very little friction on the rods, and that they will take on a beautiful brown polish. If steam blows out around the gland, tie a piece of rag around that, and shove it home.

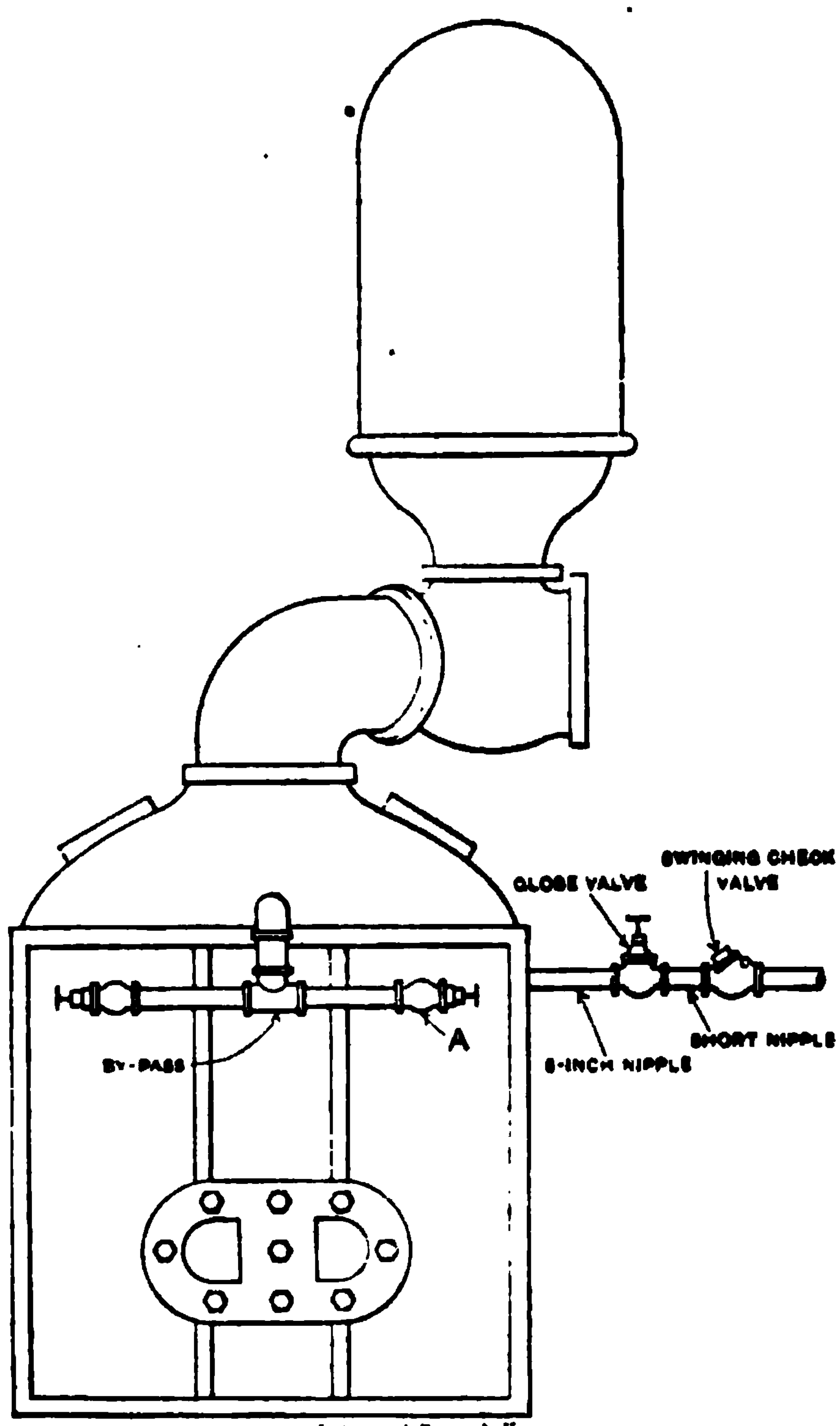
Next, are you sure that your high-pressure steam rings are not turned so that the split in them comes opposite the steam ports, causing a wasteful blow? Also center low-pressure pistons with your calipers, and be sure that the packing rings in that piston are set out in as true a circle as in you lies. Have you leaks in steam jackets that allow steam at boiler pressure to escape into low-pressure

steam chests or cylinders? I have known cases where the steam in jackets being left on all night would draw all the steam from the boilers, and condenser and air pump would be red hot in the morning. Such a leak will cause a heavy draft on the coal pile, and does no one any good. As to the locality of leaks, they are most liable to be found at bottom flanges of low-pressure steam chests. Our system of putting in gaskets is to use asbestos sheet packing, and after putting it into place wet it thoroughly so that flanges will bed themselves in it. At the place where the jacket holes come we put in extra pieces as large as fifty-cent pieces, and, of course, with holes in the center; these being also wet and stuck to the gasket reinforce the gasket at that place, and the joint will never leak. Cylinder heads are treated in the same way.

It is a good plan to go over all the bolts of the engine with a wrench occasionally, and improved vacuum, etc., will be the result. If your vacuum does n't hold steadily, search for leaks with a torch. Air leaks will usually be found, if at all, between exhaust pipe flanges on low-pressure cylinders and the air pump. I have one leak in a peculiar place; it is a blowhole in the iron at the bottom of a low-pressure piston-rod stuffing box; if the rod packing is not just right the leak affects the vacuum somewhat.

There is a difference in the way that engines must be run, for every engine seems to have an individuality of its own. For instance, one pump will run better with cross exhaust wide open, where perhaps in another the opposite will be the case. Find the point where the column of air in air chamber will give the best results. While upon this subject let me relate something that happened to me, and how we finally remedied the difficulty. One of our water takers, whose house is located on a dead end, was continually complaining of a water hammer on the service pipe. It was proposed to put an air chamber on the highest point of the service pipe, but that was objected to because it would be necessary to cut away a part of a shelf. The lady kept sending word to me about the hammer, and one day I noticed that the air chamber on the engine was nearly full of water, and the thought occurred to me that the trouble might be there; so I told the messenger that I would see what I could do to stop the trouble, and asked him to let me know the next forenoon if it still continued. That night I allowed the water to drain out of the pumps, and when starting anew the next day, of course, the air chamber was full of air. That stopped the ham-

mer on the service pipe, but I was to run up against more trouble. The people who are located on the force main began to complain of air in meters and service pipes, and so I had to invent some way to get air into the air chamber without any of it going into the mains, and without draining the pumps. The device is described and illustrated in *Steam Engineering* of November 15, 1901, from which the illustration, Fig. 2, is copied.



Device for Charging Air Chamber.

FIG. 2.

In regard to our plant, we have two engines, a Worthington cross compound condensing duplex pump, 18 by 36 by 14 by 24 inches, and a Blake tandem compound condensing pump, 12 by 24 by 14 by 18 inches, with independent air pump; also a boiler feed pump. We also have a 24-inch blower run by a Pelton water motor to obtain forced draft. We have two boilers 16 feet long, each having 72 tubes 3 inches in diameter; one boiler has lap joints double riveted; the other, butt joints with inside and outside covering plates, and is triple riveted. Our lift, including friction in force mains, is 215 feet. Our average duty is fifty-two million foot-pounds per hundred pounds of coal used, as per formula of uniform statistics.

This duty is obtained by using a fuel composed of one third bituminous coal from the Red Jacket mine, and two thirds anthracite screenings. The cost per long ton at the rate we paid for our coal last year is about two dollars and eighty-five cents. The term *duty* has very little meaning for the average man outside of those con-

cerned in water-works matters, and the gallons pumped per pound of coal is misleading, as an engine on a low lift giving low duty will show more gallons per pound of coal than a better one having a higher lift; so in my case I have thought best to find the total horse-power developed for the year, and by dividing that by the total coal find the number of pounds of coal used to develop one horse-power. That, it seems to me, is the plainest way to show to an unitiated inquirer which engine is doing the best.

Cylinder oil plays an important part in getting results from a steam jacketed engine, as one lubricator usually does all the work. Then again the M. E. P. in the high-pressure cylinder of a compound engine is so high that an oil that will not vaporize and do no good in the low-pressure cylinders is required. Therefore you will have to use considerable judgment in your selection of oil, and you will not always find that the highest priced oil is the best. Oil for your bearings should not cost over twenty cents per gallon. Grease is better, and cleaner when used in compression cups.

Be sure that the pipe that carries oil from the lubricator to the steam pipe is tapped half way into pipe, so that the oil will drop into the steam, and not run down on the inside of the pipe. Use some graphite on rods and in cylinders every day.

I know the Association will pardon me if I put in a word for the engineer. I think that universally the men who are in charge of pumping stations are conscientious and faithful, and I would ask superintendents to humor their little idiosyncrasies as regards the kind of oil, packing, etc., that they want. Personally I am fortunate in having a superintendent to whom I have only to express my preferences for material needed and it comes promptly.

Now, to sum up the whole matter, after everything about the plant is in repair, to obtain the best results is only a question of nursing; for, as I have said before, every plant has an individuality of its own, and you must study draft of chimney, in relation to the direction of wind, weight of atmosphere, etc., and govern your fires and fire accordingly. Adjust every part of your engine to give best results; find most economical pressure of steam and height to carry water in boilers and air chamber, and the most economical position of parts of engines in relation to their fellows, and you will be pleased with the results.

SMALL PUMPING ENGINES. — Topical Discussion.

[*February 12, 1902.*]

Mr. Wm. F. Codd.* At the Wannacomet Water Works, at Nantucket, for over twenty years there has been a steam pumping plant consisting of two horizontal tubular boilers, a Worthington pump, 18½ by 14 by 10 inches, and a Blake duplex pump, 8 by 6 by 10 inches, all in one building. This plant has been run successfully, without accident to require shutting down and stopping the water supply; but it was not considered safe to have the water supply of the town longer dependent on one plant, which might be crippled by fire or other accident. It was therefore decided to build an entirely separate and distinct pumping plant, principally as a reserve.

Machinery which could be laid up without much deterioration, and which could be easily and quickly put in operation, was required; and the outcome was a new pumping station, built on the opposite side of the pond from the steam station, and equipped with a Fairbanks-Morse gasolene engine of sixteen horse-power, connected by a friction clutch to a Deming triplex single-acting power pump, 8½ by 8 inches, of a nominal capacity of three hundred gallons per minute (see Plate I).

After this plant was installed, the ease and certainty of its operation, its freedom from the dust, dirt, and labor incident to a coal plant, and its generally satisfactory condition, induced us to use it in preference to the steam plant. From April to December, 1901, it pumped nearly all the water used in town.

In the winter the steam plant is used, that station being kept warm, thus protecting the pipes from freezing, etc.

Our water tank being of only fifty thousand gallons capacity, and our consumption varying from sixty thousand gallons daily in winter to three hundred thousand in summer, frequent and short runs and considerable night pumping are required, making it rather expensive, both for fuel and for engineers' services. If we had a larger stand pipe, the services of one engineer would be enough.

The gasolene plant runs as smoothly and nicely as could be wished,

* Superintendent Wannacomet Water Company, Nantucket, Mass.

PLATE I.

SIXTEEN HORSE-POWER GASOLENE PUMPING PLANT AT NANTUCKET, MASS.

yet it requires intelligent attention at intervals, to see that oil cups are filled and delivering proper amounts of oil, and that all parts are properly adjusted. Such a plant should not be left to the care of any one not acquainted with machinery, with the idea that it will run forever without getting out of adjustment.

After a run is completed, the oil cups are refilled; the engine is wiped off; a new match for starting is prepared and put in place, and the engine is ready for another run. It then requires not over three minutes from time of entering the building, to start the engine and throw in the pump, and the machinery is going at its full capacity.

We buy gasolene in barrels, shipped to us by railroad and sailing vessel, and store it in a tank made of an old, horizontal boiler we had, of about one thousand gallons capacity. It flows from the boiler-tank, by gravity, to the fifty-gallon supply tank placed in the ground just outside the building, from which it is pumped to the engine by a small pump on the side of the engine frame, worked from the crank shaft.

During the eight months the gasolene plant was used, in 1901, the

Time of running was	1 811 hours.
Duration of continuous runs	from 1 to 15 hours.
Quantity of water pumped	33 343 700 gallons.
Average dynamic head of water, including suction lift	108 feet.
Gasolene used	3 207 gallons.
Cylinder oil	44.5 gallons.
Grease	55 pounds.
Waste	115 pounds.
H. P. required to raise water	8.34
H. P. required to run pump	4.17
H. P. developed by engine	12.51
Water raised 108 feet by 1 gallon gasolene	10 400 gallons.
Water raised 100 feet by 1 gallon gasolene	11 230 gallons.
Gasolene consumed per hour	$\frac{3207}{1811} = 1.77$ gallons.
Gasolene consumed per H. P. hour	$\frac{1.77}{12.51} = 0.141$ gallons.

Duty, 9 364 932 ft. lbs. per gallon of gasolene =
1 440 759 ft. lbs. per pound of gasolene.

Cost of gasolene, at water works	15 cts. per gallon.
Total cost of gasolene	$481.00
Total cost of oil, grease, waste, and battery renewals	$41.42
Total running expense	$522.42

$\frac{522}{33\frac{1}{3}}$ = $15.60 per million gallons of water 108 feet high.
$14.44 per million gallons of water 100 feet high.

Repairs to engine and pump	nothing.
Cost of machinery set up was about	$2 000

Compared with steam plant, used in 1900, where —

Quantity of water pumped was	32 500 000 gallons.
Quantity of coal used	241 265 lbs. = 120 tons.
Cost of coal at water works about	$4.75 per ton.
To pump 1 000 000 gallons water required	624 lbs. gasolene.
To pump 1 000 000 gallons water required	7 423 lbs. coal.
(Proportion about 1 to 12 by weight.)	
Cost of 120 tons of coal	$570
Oil, waste and supplies about	50
Total cost	$620

Equal to $19.07 per million gallons 108 feet high.
$17.66 per million gallons 100 feet high.

MR. D. N. TOWER.* We have had in operation for the past four years a kerosene oil plant with a Hornsby-Akroid engine of about thirteen horse-power. This has been run from November to March in each year, averaging about one hundred and eighty days, and pumping on an average one hundred and twenty thousand gallons a day. The man starts it in the morning at about seven o'clock, and it is discretionary with him when to shut down, but it is usually in operation from twelve to fourteen hours a day. Last year the average daily consumption of oil was sixteen and nine-tenths gallons to pump one hundred and twenty thousand gallons of water; that is, about one gallon of oil to raise seven thousand gallons of water one hundred and sixty feet. It has worked very satisfactorily. The first year we had some little expense for repairs, as we did not fully understand the machine, but for the last three years we have had no trouble at all with it. There has been really no expense for attendance, because the man who starts the engine in the morning does so when he goes to his day's work, and I pay him $2.25 a day, while I can charge $3 a day for his services most of the time.

* Superintendent of Water Works, Cohasset, Mass.

FIG. 1.—KEROSENE ENGINE, COHASSET WATER WORKS.

FIG. 2.—PUMP GEARED TO KEROSENE ENGINE.

THE CONSTRUCTION OF A RESERVOIR AND STANDPIPE ON FORBES HILL, QUINCY, MASS.

BY C. M. SAVILLE.*

Mr. President and Gentlemen, — At the request of your secretary I have pleasure in presenting to you to-day a description and some details of construction of a small storage reservoir and a standpipe recently constructed for the Metropolitan Water and Sewerage Board on Forbes Hill, in Quincy. Mr. F. P. Stearns is chief engineer of this board, and the work of which I shall speak was done under the supervision of the Distribution Department, of which Mr. Dexter Brackett is engineer.

The object of the work was to furnish storage and protection to the southern part of the water district in case of accident to pumps or water mains; to provide for sudden and unusual drafts, and to act as an equalizer at this end of the system. With these ends in view, Forbes Hill was selected as offering the most favorable location. This hill is situated in Quincy, about one mile from both the Wollaston Heights and East Milton stations, on the Plymouth Division, New York, New Haven & Hartford Railroad. It is what is known to geologists as a drumlin, a hill oval in shape and composed of unstratified glacial drift or "hard pan." The summit of the hill was about one hundred and ninety feet above low water in Boston Harbor, bare of trees, and afforded a magnificent view of the surrounding country.

A map of the Metropolitan Water District showing the pipe lines and the position of Forbes Hill Reservoir, in Quincy, is shown in Fig. 1.

In designing the work it was decided that the reservoir should have a capacity of about five million gallons, and be so placed on the hill that the amount of material excavated should approximately equal that necessary for embankment. The standpipe was designed to hold about three hundred thousand gallons, with its overflow at about the elevation of Fisher Hill Reservoir, Brookline, into

* Division Engineer, Distribution Department, Metropolitan Water Works.

which the pumps at Chestnut Hill also deliver water for the high-service supply of Boston.

From the indications of a test pit dug at the point of greatest excavation and to the depth of the bottom of the proposed reservoir, the material underlying the soil was estimated to be very hard and compact, containing many stones and small bowlders and sufficient

FIG. 1.

clay to make an excellent embankment, which would be impervious to water without the use of a core wall.

As designed and built, the reservoir is oblong, with its long axis running approximately east and west. Its bottom is 280 × 100 feet in size, and slopes slightly toward a center drain, which also pitches to a sump in the west end. The slope of the surface of the banks on the water side is one foot vertical on one and three-quarters feet horizontal. The corners are rounded like the surface of an inverted

right cone, having the apex at the surface of the concrete at the bottom. The top of the bank is about seventeen feet wide, and the outer slope is one foot vertical on two feet horizontal. The inner slope and bottom are covered with concrete, extending, on the slope, about two feet vertically above high water. On top of the bank is a granolithic walk, six feet wide, encircling the reservoir. On either side of the walk and on the outer slopes the bank is laid down to grass. In order to dispose of material of a loamy nature, which it was thought unwise to use in the main banks, a berm twenty feet wide was built along the entire northerly side, where the built-up bank was highest. The gate chamber is located at the west end, partly in excavation and partly in embankment. Flights of granite steps on either side lead to the walk about the reservoir.

Nearly opposite the gate chamber is the steel standpipe, thirty feet in diameter and sixty-four feet four inches high, resting on a heavy concrete foundation, in which is a vault containing the gates for controlling the water in the standpipe. The standpipe is enclosed in a granite masonry tower, the roof of which, reached by a circular iron stairway, can be used as an observatory.

All of the above-described work is completed except the tower, which is now under construction. The plan and typical sections of the reservoir are shown in Fig. 2.

RESERVOIR.

On June 26, 1900, bids for building the reservoir and standpipe foundation were received, based on an estimate of quantities which, together with the bids, is given in Table No. 1.

The contract was awarded, July 7, to Messrs. Beckwith & Quackenbush, of Mohawk and Herkimer, N. Y. On July 16, the contractors began to bring materials and tools upon the ground and commenced erecting an office and cement shed. Almost the first thing done was to set up a single-drum hoisting engine and boiler, which by means of a wire cable helped haul heavy loads up the hill. The nearest public street was nine hundred feet away from the work. From this the way to the top of the hill rose with an almost uniform slope of ten feet per one hundred, partly over a private street and partly over the open hillside.

Excavation and Embankment. — The reservoir site was first stripped of loam to a depth of about two and a quarter feet. A sufficient quantity of this was placed in spoil banks, from which it

Cross Section C–C.

FIG. 2. PLAN OF RESERVOIR AND-STANDPIPE AND SECTIONS OF RESERVOIR.

METROPOLITAN WATER WORKS — DISTRIBUTION DEPARTMENT.

RESERVOIR AND FOUNDATION FOR STANDPIPE, FORBES HILL, QUINCY.

CONTRACT No. 198. CANVASS OF BIDS. RECEIVED JUNE 26, 1900.

	ITEMS AND QUANTITIES.		BIDDERS AND PRICES.						
			Beckwith & Quackenbush, Mohawk, N. Y.	Fallon Bros., Quincy, Mass.	Thomas & Connor, Middleboro, Mass.	Bruno, Salomone & Petitti, Boston, Mass.	Ferullo & Co., Boston, Mass.	Donato Cuozzo, Brooklyn, N. Y.	Canedella Bros., Milford, Mass.
1	Earth excavation	26 300 cu. yds.	$ 0.28	$ 0.47	$ 0.38	$ 0.33½	$ 0.50	$ 0.40	$ 0.35
2	Rock excavation	50 ,,	2.50	2.00	1.25	2.90	2.00	2.00	2.25
3	Portland cement concrete masonry (Class A)	270 ,,	8.00	6.15	7.50	7.50	7.00	7.50	7.65
4	Portland cement concrete masonry (Class B)	330 ,,	6.00	5.25	5.60	6.75	6.00	6.75	6.40
5	Am. natural cement concrete masonry (Class C)	420 ,,	5.25	4.20	4.75	5.50	5.00	5.00	6.25
6	Portland cement concrete masonry (Class D)	630 ,,	6.00	5.23	6.00	7.00	6.00	6.75	7.00
7	Portland cement concrete masonry (Class E)	1 300 ,,	7.00	6.40	7.65	8.00	7.00	7.75	8.75
8	Plastering	7 100 sq. yds.	.25	.40	.48	.45	.40	.40	.65
9	Granolithic walk	700 ,,	1.29	2.00	1.67	2.16	2.00	1.75	3.36
10	Granite ashlar masonry	8 cu. yds.	40.00	25.00	14.00	20.00	10.00	25.00	20.00
11	Granite dimension stone masonry	10 ,,	60.00	60.00	30.00	25.00	20.00	40.00	35.00
12	Brick masonry	5 ,,	18.00	14.00	16.00	15.00	10.00	13.00	20.00
13	Laying 24-inch cast-iron pipe	100 lin. ft.	.30	2.50	1.25	1.35	.40	1.50	1.50
14	...	30 ,,	.40	2.40	1.75	1.50	.50	1.75	1.50
15	...pply and drain gate chamber		120.00	250.00	570.00	250.00	75.00	250.00	280.00
16	...inch	150 lin. ft.	.50	.60	.40	.50	.35	.60	.50
17	...for		490.00	375.00	300.00	500.00	300.00	600.00	550.00
18	...	700 sq. yds.	.35	.40	.75	.25	.50	.50	1.00
19	...	300 ,,	.50	.75	.75	.75	.20	.75	2.10
20	Seeding	1 acre.	15.00	60.00	28.00	25.00	50.00	75.00	225.00
	Totals		$34 736.00	$36 355.00	$36 449.50	$37 159.50	$37 388.50	$38 085.	$42 346.00

	ITEMS AND QUANTITIES.		BIDDERS AND PRICES.					
			Bell & Co., Boston, Mass.	Joseph Ross, Boston, Mass.	Warren Bros. Co., Boston, Mass.	The C. H. Eglee Co., Boston, Mass.	Jesse Moulton, Boston, Mass.	John Cashman, Quincy, Mass.
1	Earth excavation	26 300 cu. yds.	$ 0.50	$ 0.48	$ 0.60	$ 0.48	$ 0.46	$ 0.65
2	Rock excavation	50 ,,	5.00	4.00	2.50	3.00	3.00	2.00
3	Portland cement concrete masonry (Class A)	270 ,,	10.50	10.75	10.40	10.75	9.50	8.75
4	Portland cement concrete masonry (Class B)	330 ,,	7.00	8.50	6.60	8.50	7.00	7.00
5	Am. natural cement concrete masonry (Class C)	420 ,,	5.50	5.95	5.25	5.90	5.75	6.00
6	Portland cement concrete masonry (Class D)	630 ,,	6.75	7.50	6.90	7.50	6.25	7.30
7	Portland cement concrete masonry (Class E)	1 300 ,,	8.50	8.45	9.00	10.25	9.50	9.60
8	Plastering	7 100 sq. yds.	.35	.48	.35	.50	1.00	.35
9	Granolithic walk	700 ,,	1.90	2.30	2.18	2.50	2.25	2.16
10	Granite ashlar masonry	8 cu. yds.	18.00	40.00	25.00	20.00	20.00	20.00
11	Granite dimension stone masonry	10 ,,	30.00	65.00	42.00	35.00	60.00	50.00
12	Brick masonry	5 ,,	15.00	26.00	16.00	12.00	20.00	25.00
13	Laying 24-inch cast-iron pipe	100 lin. ft.	1.00	.40	1.00	1.50	1.35	2.50
14	...	30 ,,	2.00	.50	1.50	2.00	1.50	3.00
15	...pply and drain gate chamber		250.00	300.00	250.00	200.00	200.00	209.00
16	...inch	150 lin. ft.	1.00	.60	.60	.80	.80	1.00
17	...for		250.00	425.00	315.00	125.00	350.00	500.00
18	...	700 sq. yds.	.72½	1.40	.70	.65	1.00	.75
19	...	300 ,,	1.00	1.05	.60	.90	1.00	.75
20	Seeding	1 acre.	119.00	90.00	80.00	20.50	100.00	50.00
	Totals		$42 498.00	$45 298.50	$45 714.00	$46 474.50	$46 109.00	$48 844.50

Awarded to BECKWITH & QUACKENBUSH.

was later re-excavated and placed on the outer slopes of the banks. Five of these spoil banks were built, located with especial reference to rehandling the loam as cheaply as possible. Two of them were for the blackest and best of the loam, and the others for that of a poorer quality. The remainder of the loamy material was placed in the berm with one handling. The average cost of stripping the loam is shown in Table No. 2.

After the soil was removed the material generally was found to be very compact and hard to excavate, and any water from rain or hose would stand in puddles on the surface until it was evaporated rather than absorbed. When the excavation for the gate chamber and pipe trench was made, the sides were carried down vertically for fifteen or twenty feet without any bracing whatever, and in the case of the gate chamber these walls were even battered back into the bank at the rate of 1 to 12. Twice, before concrete was put in, there was a depth of from ten to twelve feet of water in the chamber for one or two days, which drained from rain falling in the reservoir. When, however, it was pumped out, the sides of the bank seemed to have suffered no damage.

The material excavated varied somewhat, some portions being a little more gravelly than others. As a rule, however, four horses on a pavement plow, with continual cross plowing to break down the material between the furrows, was necessary.

The contractor tried blasting to loosen the material. The holes at first were drilled by hand, two men on a churn drill making about ten linear feet of holes per day. Later a steam drill was used, making about thirty feet per day. These holes were located at the corners of ten-foot squares. When the powder was exploded the ground was considerably shaken and loosened. Unfortunately, however, there came a rain storm that same night which caused the loosened material to settle back into place, apparently as solidly as ever. Later, however, it was found that this portion of the work was much more easily excavated, and the contractor was very sorry that the blasting had not been continued. The contractor himself was away at this time, and his foreman, anxious to make a good record and discouraged by the seeming mishap to the loosened material, abandoned blasting, with which for this purpose he was unfamiliar, and returned to plowing.

In order to soften the material somewhat, one or two men were employed each night to thoroughly wet the surface to be plowed the

Table No. 2.

EARTHWORK — EXCAVATION AND EMBANKMENT.

COST OF WORK.

Total quantities moved . . . . 38 334 cu. yds.
Cost $18 097.39
Cost per cu. yd. 406

Comprising the following: —

GROUP I. — Soil Excavation.
To spoil banks and berm.
From spoil bank to reservoir bank.
Quantity moved . . . . 18 868 cu. yds.
Cost $8 243.35
Cost per cu. yd. .384

GROUP II. — Material in Reservoir Bank and Backfilling Trench.
Quantity moved . . . . 18 466 cu. yds.
Cost $9 854.64
Cost per cu. yd. .534

	Nature of Work.	Cubic Yards.	Cost in Detail.									Total Cost per Cubic Yard.	Remarks.
			Loosening.	Scraping.	Loading Carts.	Teaming.	Rolling Banks.	Unloading and Spreading.	Excavation from Trenches.	Backfilling Trenches.	Surplus from Trenches to Reservoir Bk.		
GROUP I.													
a.	Stripping — To spoil banks and berm	6 722	$0.034	$0.140	. . .	. . .	. . .	$0.006	. . .	. . .	. . .	$0.180	excavated
b.	Yellow loam — Spoil banks to reservoir bank	8 601	.054	.223	. . .	. . .	. . .	.029	. . .	. . .	. . .	.306	scrapers. excavated
c.	Black loam — Spoil banks to reservoir bank	1 545	.046	.236	. . .	. . .	. . .	.096	. . .	. . .	. . .	.372	scrapers. excavated scrapers.
GROUP II.													
a.	Major part of hard-pan exc. .	15 786	.109	.223	. . .	. . .	$0.039	.077	. . .	. . .	. . .	.447	Loosened by plows; excavated and transported by scrapers.
b.	Trimming and grading slopes and bottom	1 500	.563	. . .	$0.306	$0.226	.044	.003	. . .	. . .	. . .	1.203	
c.	Exc. gate chamber, standpipe foundation, pipe trench . .	750	. . .	. . .	. . .	. . .	. . .	. . .	$0.605	$0.174	. . .	.779	
		430	. . .	. . .	. . .	. . .	. . .	. . .	.605	. . .	$0.339	.944	

next day. This scheme succeeded admirably if care was exercised not to get the ground too wet and if it was possible to excavate the damp material before it dried and became hard again.

In starting the embankments, the ground was first thoroughly cleaned of loamy material to a depth of at least two and one-half feet, for a distance inward from the outer toe of the slope equal to about one third the width of the bank. At this point a quick drop of about one foot was made and excavation continued at this depth for about another third of the width, when a second drop of about one foot was made and the excavation carried at such a depth that at the inner edge of the bank it would be about five feet below the original surface. This method stripped from under the banks all soil, and practically removed from the inner third all material that could have been disintegrated by frost. In stepping down no attempt was made to get the sharp corners often shown on plans, as it was thought that the material could be packed more solidly against a sloping surface than in the apex of a sharp re-entrant angle.

The bank was started in the lowest places, the undisturbed material being well wet and thoroughly rolled before placing other material upon it. The contractor had a number of methods of work somewhat unusual about Boston, but common enough in some other parts of the country. Some of the methods, under proper circumstances, deserve more extended use. The work of excavation is shown in Plate I, Fig. 1.

All the excavation, except a few hundred cubic yards in the bottom of the reservoir, was done either with wheel or drag scrapers. The wheel scrapers resemble immense square-pointed coal scoops, and are drawn by two horses. They are so balanced on two iron wheels that, by means of handles behind, the cutting edge can be lowered, and when the scraper is pulled ahead the material is pushed up into the bowl of the scraper. When full, by bearing down on the handles, the cutting edge is raised, and an iron hook automatically catches and holds the bowl in place until the dumping ground is reached; the hook being then released, the cutting edge strikes the ground, and the load is dumped by the movement of the horses which overturns the scraper.

The drag scrapers are similar in shape, but without the wheels.

The ordinary gang on the work in the hard pan was made up of a four-horse hitch on a pavement plow, one man driving and one or

PLATE I.

FIG. 1. — EXCAVATION AND BANK BUILDING.

FIG. 2. — BUILDING RESERVOIR BANKS.

two men on the handles; four or six scrapers, depending on the length of the haul; an extra pair of horses, called a "snap team," which helped load each scraper; a man to hold the scraper handles while loading; and, if the material was very hard to excavate, two or three extra men to complete the scraper load with shovels. The haul for the wheel scrapers was not over two hundred and fifty or three hundred feet, and for the drag scrapers about one fourth of this distance.

Theoretically, the wheel scrapers carried about three fourths of a cubic yard and the drag scrapers about one half this quantity. Under favorable conditions in a soft or sandy soil they would undoubtedly take this amount; but in the material here excavated not more than one half as much was excavated per load. At first sight this seems a small amount; but if properly regulated for distance and number of scrapers to a gang, an immense amount of material can be moved in a short time, and at a small expense. When the work was well under way in the hard-pan excavation, under favorable conditions of haul, each team averaged thirty-five cubic yards per day, and under unfavorable conditions thirty cubic yards, making from eight to ten trips per hour.

Excavation by scraping is hard on both horses and driver, as the team is continually in motion.

Even under the adverse condition of the material here excavated, the use of scrapers was found to be much more economical than cart work while the banks were low and the haul short. This was demonstrated on the work as follows: —

One forenoon two of the scrapers were out of commission for repairs, and two others were taken off, leaving one gang of four scrapers at work. Single tipcarts were substituted for the other scraper gang. A careful record was kept of the work done by these two methods, which proceeded side by side and under identical conditions. Without including charges for foreman and for loosening the material, which were the same under both methods, it was found that four scrapers, one snap team, and four men beside the drivers moved to the banks one hundred cubic yards of hard pan in five hours at a cost of fifteen and one-half cents per cubic yard; while six carts with fourteen men beside the drivers moved seventy-five cubic yards in the same time at a cost of twenty-four cents per cubic yard. The quantities moved during this time were more than were generally averaged, as the gangs were working against each

other; nevertheless, the proportionate relation of the methods under similar conditions of haul and material holds good.

Three rollers, each weighing about four thousand pounds and drawn by two horses, were used on the banks. These rollers were composed of gangs of separate cast-iron wheels, the alternate ones being of larger diameter than the others. Two of these rollers were four feet wide and the other about six feet wide. The method of building and rolling the banks is shown in Fig. 2 of Plate I.

In order to provide water for wetting the bank and later for the concrete work, a one and one-half inch wrought-iron pipe was laid entirely around the reservoir, a distance of about fifteen hundred feet. This pipe had hose connections about fifty feet apart, controlled by small valves. The pipe was connected at both ends with the twenty-four inch main, but when a number of streams were wanted at the same time and through long lengths of hose, considerable trouble was found in getting a sufficient supply in those portions farthest from the main. Three-quarter inch hose was used, and a nozzle throwing a fan-shaped spray gave excellent results. By this means water could be applied where needed, and places already sufficiently wet could be avoided.

The banks were put down in layers four inches thick before rolling. Parallel with the axis of the bank the layers were kept approximately level; crosswise they were given a slope toward the reservoir of about 1 in 50. Beginning at about three feet from the top, this slope was gradually changed to a very slight pitch outward, to keep water falling on the top of the bank from washing the inner slopes when ready for concrete.

Just before placing the dry material, the place where it was to be dumped was thoroughly soaked, then the load was dumped and partially leveled by the scraper edge. Laborers then spread the layer evenly, picking out stones larger than about three inches in their greatest diameter, especially those which would project above the layer when rolled. As great care as possible was also taken that a number of smaller stones should not lie together, but that they should be separated by the hard pan. When a sufficient length of bank had been spread, the roller was run over it three or four times to break up any lumps, consolidate the material, and drive up water from the under layer. After this it was sprinkled and rolled until the whole surface had a fresh, bright appearance and the wheels of the roller left only a faint impression upon it. Sufficient water was

constantly applied under this second rolling to make the material plastic, but not liable to peel under rolling. After a little experience the proper amount of water could be determined by inspection, but no rule could be followed, as the material varied so in the amount of clay it contained.

If the bank was too wet, either from sprinkling or from rain, it would rise in a wave in front of the roller, and work had to be stopped at that point until the bank had dried. On this account some difficulty was found in keeping laborers. Just after a rainy day or two, even if the weather were fair and clear, excavation could not be carried on, as the banks were not sufficiently dry to be worked on, and the material was too wet to be properly laid down. Usually the banks were ready for work long before the material could be excavated.

As a rule, the banks were kept level as stated. At the southwest corner, however, the bank was left low for a time on account of the roadway for bringing the last of the material from the bottom and carrying in materials for concrete work. On the easterly end, during the latter part of the work, the bank was built to grade as soon as possible, in order that concrete work might start. The layers of the embankment in these places were stepped back at the rate of about ten feet for each four-inch layer.

In order that that portion of each layer near the inner slope might be rolled as thoroughly as others, the bank here was built with an extra width of about a foot, and this excess portion trimmed off just before the concrete lining was laid. The trimming of these slopes, the excavation to grade in the bottom, and the taking out of the roadway were the most expensive parts of this work.

An idea of the comparative cost of this work is to be had from Table No. 2. The slopes were plowed twice, and the material cast down the bank to the bottom. At first drag scrapers were tried, but were soon abandoned for pick and shovel, as the scrapers dug so deeply and unevenly into the bank.

Carts were used for transporting materials excavated on this portion of the work. They were of a pattern seldom used here, being of the self-dumping variety, holding from one and one-half to two cubic yards, and drawn by two horses. Being somewhat longer than the usual two-horse dump cart, they allowed a larger gang of men to work around them while being loaded. When the dump was reached, without stopping his horses, the driver with one hand re-

leased a pawl, which allowed the two leaves forming the bottom to swing downward, dumping the load. On the way back, by means of a lever and chain working over a sprocket wheel, he would draw up the bottom, ready for the next load.

The method employed with these carts was to have two of them for one pair of horses, and while one cart was on its way to unload the other was being filled. On his return the driver would change his horses to the now-loaded cart, leaving the empty one to be filled. Beside utilizing the horses, which are the most expensive item in team work, to their utmost capacity, the laborers also were urged along by the fact that the cart must be loaded by the time the horses returned. Beside being easily unloaded, materials could be landed by these carts in places where ordinary carts could not be drawn and dumped.

When November of 1900 came, finding the embankments and excavation still far from completion, it was decided to protect the banks during the winter by filling the reservoir with water. The banks were built to elevation 189, six feet below the top of the finished bank and three feet below the top of the hard pan. A belt of riprap (see Plate II, Fig. 1) about five feet wide and six to eight inches thick was laid around the top of the bank to protect it from wave action, and water was admitted very slowly up to about the middle of the riprap belt. Two weeks were taken to raise the water level ten feet, in order that the banks might not be too suddenly disturbed and slide. Frequent levels were taken on the water surface during the winter, and the entire hillside was carefully examined for any unusual flow of water. During this time the surface lowered very little, not more than could be ascribed to evaporation from water in such a high and exposed place.

In the spring the rains filled the reservoir so rapidly that it was necessary to lower the surface eight or ten inches very quickly. The outlet into which the reservoir drain discharged not being of sufficient size to care for so large a quantity of water in so short a time at this season, when the natural drainage was itself very large, another temporary outlet had been planned and was in process of construction. This was not quite in condition for use, and as there seemed a possibility, at least, that the water might overtop the banks, two wrought-iron pipe siphons, one four inches and the other one and one-half inches, were set up and used for a day or two until the temporary outlet was ready. Previous to setting up the

PLATE II.

FIG. 1. — CONDITION OF WORK AS LEFT FOR WINTER OF 1900.

FIG. 2. — ENTRANCE TO GATE CHAMBER.

pipes, a very successful siphon was made with the suction hose from an ordinary diaphragm pump.

After this the water was withdrawn very slowly and the banks carefully watched for cracks and slides. A slight slide of a few cubic feet occurred while the water was being lowered at the rate of three quarters of an inch per hour. The rate was at once reduced one third, and no further trouble occurred.

Before leaving the work in the fall, levels were taken over the embankments, and in the spring were again taken in the same places, but no settlement was apparent.

After the hard-pan portion of the banks was finished and the concrete work nearly done, yellow and black loam was taken from the spoil banks and put on the outer slopes. Here a feature of the scraper work was developed that should be taken into account in similar work. It had been expected that there was plenty to put two feet of yellow and one foot of black loam on the banks and still have a surplus remaining.

After a short time it was seen that the yellow loam surplus was not to be as great as had been expected, and directions were given to cut down the depth of the loam layer six inches in order to have an even layer over the whole surface. In looking about for the cause of this reduction, it was found that the amounts scattered by the scrapers in taking the long haul from the loam piles to the banks fully accounted for it. After the loam piles were all removed, except one which still remains at the west end for future use, the ground all about the reservoir was plowed up, harrowed, and sowed to grass. After the banks were covered with soil they too were sowed with grass seed and winter rye, scattered over with fertilizer, and rolled.

It was estimated that about 1 043 cubic yards of stone, too large to be rolled into the banks, were picked out from the excavated material. The greater part of this stone was removed by a gang of men and a cart following the plows. A considerable portion, however, was thrown out from the layers as spread on the bank. This stone was thrown over the outside of the slope. Below the berm it was allowed to be buried. Above the berm it was removed to the stone piles. To provide drainage for any water which might collect in this stone layer, cross ditches filled with stone were dug through the berm from fifty to seventy-five feet apart.

Most of the stone was placed in piles, and afterward either

crushed and used in the concrete or placed in the foundations of the walk and driveway. Table No. 3 shows the quantities of material excavated during this work and their final disposition. Table No. 2 shows the cost of the excavation in detail.

Table No. 3.

QUANTITIES — EXCAVATION AND EMBANKMENT.

Total quantity of material moved			32 334 cu. yds.
1st Handling.			
Black loam to spoil banks		2 414 cu. yds.	
Yellow loam to spoil banks		3 808 ,,	
Yellow loam to berm		2 500 ,,	
2d Handling.			
Black loam spoil banks to reservoir bank		1 545 ,,	
Yellow loam spoil banks to reservoir bank		3 601 ,,	
2d Handling.			
Material used in main portion of (trimming inside slope) reservoir bank		1 000 ,,	14 868 ,,
			17 466 cu. yds.
* Stone from Excavation.			
Used for concrete	1 495 x 54% solid	807 cu. yds.	
Used for foundation of walk	232 x 50% ,,	116 ,,	
Used for foundation of drive	140 x 50% ,,	70 ,,	
Spoiled in berm	100 x 50% ,,	50 ,,	1 043 ,,
Material used in main portion of reservoir bank			16 423 cu. yds.
Volume in main portion of reservoir bank			15 474 ,,
Shrinkage in material used — Quantity			949 cu. yds.
— Percentage			6%
Material excavated for use in main portion of reservoir bank			17 466 cu. yds.
Volume in main portion of reservoir bank			15 474 ,,
Shrinkage in material excavated — Quantity			1 992 cu. yds.
— Percentage			11.4%
Material excavated for use in main portion of reservoir bank			17 466 cu. yds.
Quantity of solid stone in same			1 043 ,,
Percentage of stone removed from material excavated			5.9%

During the time when the work was well under way the average force employed on excavation and embankment was : —

Classification.	*Number Employed.*	*Rate of Pay.*	*Cost.*
General foreman	0.9	$4.00	$ 3.60
Subforeman	1.0	3.00	3.00
Timekeeper	.8	2.50	2.00
Water boys	7.0	.75	5.25
Carpenter	.5	2.50	1.25
Laborers	28.0	1.50	42.00
Teamsters	20.0	1.50	30.00
Horses	40.0	1.25	50.00
Daily pay-roll			$137.10

* Stones were removed only from material to be used in building embankment.

Proportional time only is given to general foreman, subforeman, timekeeper, and carpenter, the remainder of their time being devoted to other work in progress at the same time. The price for horses during 1901 was $1.50 each. The above force comprised three gangs on plowing and loosening and two gangs each on scraping, rolling, and spreading on the banks. From four to six scrapers were employed in each scraper gang, both gangs moving a maximum of 1 050 loads, or about 400 cubic yards per day. When the work was on the trimming and grading of banks this force was greatly reduced.

Concrete Masonry.

Concrete masonry (Class A), composed of 1 part of Portland cement, 2½ parts of sand, and 4 parts of stones, was used for the walls and bottom of the gate chamber, for the walls and floor of the gate vault in the standpipe foundations, and for cut-off walls on the pipe line.

Concrete masonry (Class B), composed of 1 part of Portland cement, 3 parts of sand, and 6 parts of stones, was used for the foundation of the standpipe and for the foundations of the steps of the gate chamber.

The bottom and slopes of the reservoir were lined throughout with two layers of concrete masonry separated by a layer of Portland cement plaster one-half inch in thickness.

Concrete masonry (Class C), composed of 1 part of American natural hydraulic cement, 2 parts of sand, and 5 parts of stones, was used for the under layer of concrete on the bottom of the reservoir.

Concrete masonry (Class D), composed of 1 part of Portland cement, 2½ parts of sand, and 6½ parts of stones, was used for the under layer of concrete on the slopes of the reservoir.

Concrete masonry (Class E), composed of 1 part of Portland cement, 2½ parts of sand, and 4 parts of stones, was used for the upper layer of concrete on the bottom and slopes of the reservoir.

It was specified that the cement should be properly tested, that the sand should be of approved quality, and that either clean gravel stones or crushed rock should be used in the aggregate. None of the stones were to be larger than two and one-half inches in their greatest diameter, and those used in the upper layer in the reservoir lining were limited to one and one-half inches.

It was also provided that this upper layer should be formed in blocks, half of the blocks, alternating in both directions, being first

made and allowed to set. The surface of these blocks was to be finished smooth and true to the slope required, and if plastering was necessary to obtain this, it was to be applied before the concrete had set. The whole cost of such plastering was to be included in the price stipulated for Class E concrete.

The quantity of concrete masonry paid for was that deposited in place in accordance with the plans and specifications.

About 4 350 barrels of cement were used on the work, 3 850 being Atlas Portland and the remainder being either Hoffman or Beach's natural cement. The Portland cement was put up in both barrels and bags, while the natural cement all came in bags. For testing, one sample was taken from the equivalent of each five barrels. All of the cement showed excellent results under the tests applied, which were those ordinarily employed for fineness, time of setting, tensile strength, and checking.

From the measurement of one hundred and fifty Atlas cement barrels the cubical contents between the heads was found to average 3.54 cubic feet per barrel, and from top to bottom with the heads out the cubical contents was 3.75 cubic feet.

In measuring stone and sand for the concrete, 3.7 cubic feet was the amount allowed per barrel by the specifications.

The following information concerning cement packages used on the work is given as the result of numerous determinations : —

Barrel full of cement (Atlas) weighs		402.8 lbs.
Barrel empty	18.5 lbs.	
Paper in barrel	.7 „	19.2 „
Net weight of cement in barrel		383.6 lbs.
Average weight per bag full of cement (Atlas)		96.6 lbs.
Average weight per bag empty		.6 „
Average weight of cement in bag		96.0 lbs.

Four bags of this cement were used as the equivalent of one barrel.

For the natural cement it was assumed that the net weight of cement per barrel should be about three hundred pounds.

Average weight per bag full of cement (Hoffman)	148 lbs.
Average weight per bag empty	2 „
Average weight of cement in bag	146 lbs.

Two bags of this cement were taken as the equivalent of one barrel.

Average weight per bag full of cement (Beach)	104.4 lbs.
Average weight per bag empty	.9 „
Average weight of cement in bag	103.5 lbs.

Three bags of this cement were taken as the equivalent of one barrel.

During 1900 the Portland cement was delivered on the work at the following cost per barrel: —

On board cars at East Milton	$2.11
Unloading, teaming, and storing (contract)	.12
	$2.23

During 1901 Portland cement was reduced in price, and cost per barrel on the work: —

On board cars at East Milton	$1.45
Unloading, teaming, and storing	.08
	$1.53

The natural cement cost: —

On board cars at East Milton	$1.00
Unloading, teaming, and storing	.08
	$1.08

Barrels returned to the factory are nominally worth twenty-five cents each, but on account of freight, broken and stolen barrels, etc., it is only safe to estimate on a rebate equivalent to five cents each for the whole number of barrels of cement bought, if care is taken to return the empty barrels.

If the cement is bought in bags of four per barrel, much greater saving is possible. The bags are nominally worth ten cents each, or forty cents per barrel, and as they can be packed in small space, are easily cared for and not readily damaged, they are worth an equivalent of thirty cents per barrel of cement bought after deducting all charges. On this basis the net cost of cement per barrel or per bag based on return of bags or barrels would be: —

	Delivered in Barrels.	*Delivered in Bags (4 bags = 1 barrel).*
Gross cost	$2.23	$2.23
Rebate	.05	.30
Net cost	$2.18	$1.93

Thus, if a large amount of cement is required which is to be used

quickly, there is a considerable saving in buying in bags. During 1900 no barrels or bags were returned. During 1901 the cement came in bags, which were nearly all returned.

Table No. 4.

SHOWING DISTRIBUTION OF CEMENT USED IN CONCRETE MASONRY FOR RESERVOIR LINING, GATE CHAMBER, AND FOUNDATION FOR STANDPIPE.

DESIGNATION.	Proportion.	Quantities.		Amount Laid per Barrel of Cement.			Barrels of Cement per	
		Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Ft.	Sq. Yds.	Cu. Yd.	Sq. Yd.
Concrete — Class A[1]	1:2½:4	279	. . .	0.74	20.	. . .	1.35	. . .
Concrete — Class B[2]	1·3·6	284	. . .	.94	25.4	. . .	1.07	. . .
Concrete — Class C[3]	1·2:5	400	. . .	.80	21.6	. . .	1.25	. . .
Concrete — Class D	1:2½:6½	615	. . .	.93	25.1	. . .	1.08	. . .
All except slope finish	1:2½:4	1 232	. . .	.73	19.7	. . .	1.37	. . .
Slope finish[3]	1:2½ 4	100	3 300	.89	24.	33.1	1.12	0.03
Plaster[4]: Base, ⅛-in. thick	1:1	21.2	1 530	.22	5.9	15.6	4.6	.06
Base, ¼-in. thick	1 2	73.5	5 293	.31	8.3	23.1	3.2	.05
Top finish, $\frac{3}{16}$-in. thick	1:0	16.5	6 692	.14	3.8	57.8	7.2	.02
Granolithic walk: Base	1:3:5	90	695	.83	22.3	6.2	1.2	.16
Top finish	1·1½	19.3	695	.26	7.1	9.5	3.8	.11

[1] Gravel stone used in this concrete, broken stone used in remainder of concrete.
[2] Natural cement, all other Portland cement.
[3] "E" concrete left 1-in. low on slopes and smoothly finished with mixture having stone dust containing particles less than ⅜-in. diameter substituted for broken stone.
[4] Proportion changed from 1:1 to 1:2, as it was thought less likely to crack if more sand was used.

The sand used was for the most part of excellent quality, some coming from a pit in Avon and the remainder from Milton, either from a pit opened for the purpose or from an excavation for the Metropolitan sewer trench at the foot of the hill. The Avon sand weighed about 93 pounds per cubic foot, and although very clean and sharp was a little too fine for concrete work. The pit sand from Milton was of fair quality if care was taken to thoroughly strip the loam from the surface. The best sand was that which came from the sewer trench; this had all the requisite qualities, — coarse enough, sharp, and thoroughly clean, as it was excavated from a water-bearing stratum.

During 1900 the cost of sand delivered on the hill was $1.13 per cubic yard.
During 1901 the cost of sand delivered on the hill was $1.02 per cubic yard.

The greater part of the stone used in the concrete was obtained from the excavation and crushed on the ground. Previous to setting up the crusher, about seven hundred and fifty cubic yards of gravel stones were bought. These stones were taken from a gravel bank at the foot of the hill, passed through a power screen, supposedly rejecting sizes above two and one-half inches and those below three eighths of an inch. These stones were delivered on the hill for $1.13 per cubic yard. The average weight of this gravel was 111.3 pounds per cubic foot. It was very dirty, and before using it had to be thoroughly washed. The method employed was to fill an iron wheelbarrow with the stones, tip the barrow a little, and allow water from a hose to run through the gravel till the waste water was clear.

After the stone-crusher was put up, about two hundred cubic yards of gravel stones which had not been used were run through the crusher, the screen being set to reject sizes below one-half inch. This stone had lain spread out in the hot sun for several months and was thoroughly dry. The shaking it received going through the crusher removed all dirt, which with the fine stone dust was discharged in a pile by itself. This was the most inexpensive way of getting the stone into satisfactory condition, for beside the dirt there were a great many stones of sizes too large for the concrete work. The stone-crushing plant consisted of a twelve horse-power Hoadley engine belted to a 9 x 15 Farrel Foundry and Machine Company's crusher. The engine also ran the stone elevator and the revolving screen. The rated capacity of the crusher was

125 tons, or about 97 cubic yards per day; but if a third of this work was done without some part of the machinery giving out, it was considered a good day's work.

The stone bin had a capacity of about thirty cubic yards; it was separated into three compartments, one for sizes of stone up to one and one-half inches, a second for sizes between one and one-half inches and two and one-half inches, and a third for larger stone. The stones from the third bin were teamed back to the crusher and passed through it again. At first everything smaller than one and one-half inches was allowed to pass into the first compartment and used thus in the concrete; after a while, however, it was found that so great a quantity of stone dust was coming that it had the effect of adding more sand to the concrete mixture. This was probably caused by the condition of the jaws of the crusher, which were worn so smooth that they ground the stone rather than broke it. To remedy this the screen was arranged to discharge everything less than one-fourth inch in a pile by itself. A much better concrete resulted, and some of the fine screenings were later used in finishing the surface of the concrete on the slopes. The best results in all the concrete work were obtained by using the gravel stones which varied in size, or the "run of crusher" with the broken stone. Stones all of the same size — "road metal" — were always avoided. The stone crushed on the hill was mostly trap rock or a hard slate; this stone as crushed weighed, loosely packed, about 95 pounds per cubic foot. The 1½ to 2½ inch stone had 49 per cent. voids; the 1½ inch and less, 43 per cent.; the 2½ inch and less, — "run of crusher," — 46 per cent., and the gravel stones used during the first of the concrete work only 40 per cent., of voids. In estimating the amount of voids, the stone was thrown into a barrel, without ramming, and weighed. Water was then put into the barrel until it rose level with the surface of the stone. The barrel, stone, and water were then weighed. From the weight of the water its volume was calculated and the result assumed as the voids in the barrel of stone. It was estimated that the voids were decreased from seven to ten per cent. by ramming.

The cost of the stone-crushing and of the stone used in the concrete appears in Table No. 5. In this cost there appears a charge of forty cents per cubic yard for stone, concerning which the following explanation is made: In the spring of 1901, Messrs. Beckwith & Quackenbush, the contractors, having on hand considerable other

work at a distance from Quincy, made an arrangement with Messrs. Taylor, Carr & Andrews, of Boston, contractors for concrete work,

Table No. 5.

COST OF STONE USED IN CONCRETE.

Cost of Crushing Stone.		
Lumber in bin and platform, 9 M. spr., @ $20; 20 posts, 10″ x 4′, @ 50c.		$ 190.00
Labor		1 221.00
Rent of crusher	67 days, @ $3.00	201.00
Rent of engine	67 days, @ $1.50	100.50
Coal	32 tons, @ $4.45	142.00
Oil and supplies		50.00
Total cost		$1 904.50
Stone Crushed.		
From excavation		1 495 cu. yds.
Gravel stones		200 „
		1 695 cu. yds.
Cost of crushing stone	$\frac{1\,904.50}{1\,695} =$	$1.12 per cu. yd.
Stone purchased	1 495 cu. yds., @ 40c.	$598.00
Gravel purchased	200 „ @ $1.15	230.00
	1 695 cu. yds. cost	$828.00
Average cost of stone bought for crushing, per cu. yd.		$ .49
Average cost of crushing stone, per cu. yd.		1.12
Average cost of 1 695 cu. yds. stone used in concrete, per cu. yd.		$1.61
Cost per Cubic Yard of Stone Used in Concrete, 1901.		
Stone crushed on work	1 695 cu. yds., @ $1.61	$2 728.95
Gravel purchased	81 „ @ 1.15	93.15
Crushed stone purchased	210 „ @ 1.45	304.50
	1 985 cu. yds. cost	$3 126.60
Average cost per cu. yd. of stone used in concrete, 1901		$1.57
Cost per cu. yd. of gravel stones used in concrete, 1900		$1.13

to finish the concrete then remaining to be done. This included concrete of Classes C, D, and E, the plaster work, and the granolithic walk. The stone above mentioned had been saved by Messrs. Beckwith & Quackenbush to be crushed for the concrete, and part of their arrangement with the concrete contractors was to buy this stone as it lay for forty cents per cubic yard, based on the concrete measurements, together with about three hundred cubic yards of gravel stones that had been left over from the concrete work the previous year. The stones taken from the excavation were scattered over a considerable area, and they were very dirty from the clayey material which adhered to them. One of the principal causes of the high cost

of this stone was the expense of picking up and washing previous to crushing.

All of the concrete was mixed and placed by hand. Instead of using barrels to gage the sand and cement, boxes without bottoms were made which, when placed on the mixing board or mortar box and filled, would hold the quantity required to be used with one barrel of cement. The following sized boxes were found convenient: —

Proportions of Concrete.	Sand Box.		Stone Box.	
	Size.	Volume. Cu. Ft.	Size.	Volume. Cu. Ft.
1—2½—4	2′ 9″ x 2′ x 1′ 8″	9.25	5′ x 4′ 5¼″ x 8″	14.80
1—3—6	2′ 9″ x 2′ x 2′ 0″	11.10	5′ x 6′ 8″ x 8″	22.20
1—2—5	2′ 9″ x 2′ x 1′ 4″	7.40	5′ x 5′ 6⅝″ x 8″	18.50
1—2½—6½	2′ 9″ x 2′ x 1′ 8″	9.25	5′ x 7′ 2½″ x 8″	24.05

All concrete except that put upon the slopes was mixed moderately wet and rammed with a heavy, round-ended rammer until the mass quaked. From this method no "rat holes" were found in this concrete when the forms were removed. By the use of a spade to puddle the material next the forms, a firm, smooth finish was given to the faces. As to the probability of a concrete wall being impervious to water it is only necessary to state that there is in the gate chamber a partition 23 feet high, 11 feet wide, and 3 feet thick, against which there is a head of 19.5 feet of water, on which in dry weather there is not even moisture. No especial pains were taken with this wall, nor was any waterproofing used in it. On the slopes it was not possible to place a wet mixture of concrete, and here comparatively little water was used. This concrete was rammed with flat rammers about six inches square until moisture just appeared on the surface. If the ramming was longer continued or if the mixture was even a little too wet, the mass would flow down the slope. The method which gave the best results was to mix a batch rather wet and scatter it in a thin layer next the earth bank, on top of this placing the dry layer and ramming it well into the layer below. In all cases where concrete was laid on the earth, the surface was first thoroughly wet, so that the water might not be drawn from the concrete. As the upper layer on the slopes could not be put on wet enough to finish smoothly, it was left about one inch low and finished

like a granolithic walk with a wet mixture, troweled and worked until dry and hard. Great care was taken to apply this layer before the under concrete began to set. Usually it was applied at once, and in no case later than twenty minutes after the under layer was placed. This finishing layer was mixed in the same proportions as that used in the rest of this class of concrete, 1 — 2½ — 4, but stone dust and particles less than one-half inch in diameter were substituted for the one and one-half inch broken stone. The cost of this work is shown in detail in Table No. 6.

Table No. 6.

COST OF CONCRETE WORK.

CLASS A CONCRETE. 1 — 2½ — 5. — PORTLAND CEMENT.

279 cu. yds. in plan.

Cement	1.35 bbl., @ $2.23	$3.010
Sand	0.46 cu. yd., @ 1.13	.521
Stone	0.74 ,, @ 1.13	.840
Lumber for forms	M., @ 20.00	.495
Labor.		
General expenses	$ .202	
Forms	.586	
Mixing and placing	1.147	
		1.955
Cost per cu. yd.		$6.821

CLASS B CONCRETE. 1 — 3 — 6. — PORTLAND CEMENT.

284 cu. yds.

Cement	1.07 bbl., @ $2.23	$2.390
Sand	0.44 cu. yd., @ 1.13	.497
Stone	0.88 ,, @ 1.13	.994
Lumber for forms	M., @ 20.00	.127
Labor.		
General expenses	$ .154	
Forms	.214	
Mixing and placing	.967	
		1.335
Cost per cu. yd.		$5.337

CLASS C CONCRETE. 1 — 2 — 5. — NATURAL CEMENT.

400 cu. yds.

Cement	1.25 bbl., @ $1.08	$1.350
Sand	0.34 cu. yd., @ 1.02	.347
Stone	0.86 ,, @ 1.57	1.350
Lumber for forms	M., @ 20.00	.090
Labor.		
General expenses	$ .08	
Forms	.10	
Mixing and placing	1.17	
		1.350
Cost per cu. yd.		$4.487

Class D Concrete. 1 — 2½ — 6½. — Portland Cement.

615 cu. yds.

Cement	1.08 bbl., @ $1.53		$1.652
Sand	0.37 cu. yd., @ 1.02		.377
Stone	0.96 „ @ 1.57		1.507
Lumber for forms	M., @ 20.00		.016
Labor.			
General expenses		$ .177	
Forms		.121	
Mixing and placing		1.213	
			1.511
Cost per cu. yd.			$5.063

Class E Concrete. 1 — 2½ — 4. — Portland Cement.

1 322 cu. yds.

		Cost per Sq. Yd.	Cost per Cu. Yd. Partial Quantity.	Cost per Cu. Yd. Total Quantity.
(*a*) Not including slope finish — 1 222 cu. yds.				
Cement	1.37 bbl., @ $1.53	..	$2.09	$1.940
Sand	0.47 cu. yd., @ 1.02	..	.48	.441
Stone	0.745 „ @ 1.57	..	1.17	1.083
Lumber	M., @ $20.00	..	.25	.277
Labor.				
General expense		..	.15	.143
Forms		..	.26	.236
Mixing and placing		..	1.53	1.416
Average cost per cu. yd. for 1 222 cu. yds.		..	$5.93	..
(*b*) Slope finish — 100 cu. yds. or 3 600 sq. yds.				
Cement		$ .048	$1.71	$ .129
Sand		.011	.39	.029
Stone		.026	.96	.073
Labor.				
Mixing and placing		.069	2.50	.189
Average cost per cu. yd. for 100 cu. yds.		..	$5.56	..
Average cost per cu. yd. for 1 322 cu. yds.		..		$5.911
Average cost per sq. yd. for 3 600 sq. yds.		$ .154		

Plastering — 6 822 sq. yds.

		Cost per Sq. Yd.
Cement	0.07 bbl., @ $1.53	$ .103
Sand	0.012 cu. yd., @ 1.02	.012
Labor		.083
Burlap		.002
Average cost per sq. yd.		$ .200

Granolithic Walk — 695 sq. yds.

	Cost per Sq. Yd.	Cost per Cu. Yd.
1. Foundation, 232 cu. yds.		
Stone	$ .134	$ .40
Labor, placing	.502	1.50
Average cost per sq. yd.	$ .636	
Average cost per cu. yd.		$1.90

		Cost per Sq. Yd.	Cost per Cu. Yd.
2. Concrete Base, 90 cu. yds.			
Cement	1.22 bbl., @ $1.58	.242	$1.87
Sand	0.50 cu. yd., @ 1.02	.066	.51
Stone	0.84 cu. yd., @ 1.57	.170	1.32
Labor		.450	3.48
Average cost per sq. yd.		$ .928	
Average cost per cu. yd.			$7.18
3. Top Finish.			
Cement	0.11 bbl., @ $1.58	.168	
Sand	0.022 cu. yd., @ 1.02	.022	
Lampblack		.008	
Labor		.149	
Average cost per sq. yd.		$ .347	
Total average cost of walk per sq. yd.		$1.911	

In connection with the use of stone dust in mortar, it is interesting to note that briquettes in which it is substituted for sand show a much higher tensile strength, and, in the work on the East Boston Tunnel, stone dust has entirely taken the place of sand.

All the concrete when laid was kept thoroughly wet. After it was set hard enough not to be washed, it was sprinkled once an hour during the day and sometimes into the evening for at least two days. After this, for three or four days, it would be well wet from four to five times per day, and then once in the morning and again in the afternoon, until covered with other concrete or until the work was completed.

The ordinary composition of a concrete gang was one subforeman, two men gaging materials, two men mixing mortar, three men turning concrete, three men wheeling concrete, one man placing, and two men ramming. Two concrete gangs were usually employed, and under ordinary conditions placed about twenty cubic yards per day per gang, or about 1.43 cubic yards per day per man employed. Beside these gangs, three plasterers and three helpers were employed on the slope finishing: on the bottom the material was put in so wet that one plasterer was able to finish for a gang of concrete men. This concrete was mixed on a wooden mixing platform about twelve feet square, and was always turned three times before being placed.

The upper layer, on both bottom and slopes, was put in in blocks, one-half, alternating in both directions, being first made and allowed to set. On the bottom these blocks were ten feet square, and on the sides they were about eight by ten feet. The following method was employed in laying the concrete in these blocks: The surface of the plaster layer was laid off into parallelograms of required size by

spots of black paint. On two adjacent lines of spots, three- by four-inch scantlings, with the four-inch side vertical and just ten feet apart inside to inside, were laid completely across the reservoir. On the next two rows of spots the same thing was done. This left a clear space of ten feet between scantlings in every other row. In these ten-foot rows crosspieces were laid so that every other square thus formed would be of the required length. These squares were filled with concrete first, and it was allowed to set. When ready the crosspieces were removed, and the remaining spaces in the ten-foot sections were filled. After this all the longitudinal scantlings were removed, leaving vacant rows ten feet wide alternating with ten-foot rows filled with concrete. The vacant rows were now similarly blocked off by crosspieces, sand bags being used to keep the crosspieces in place. In order to hold the scantlings on the slopes, stakes were driven through the under layer into the bank. These stakes were so placed that they came in the alternate rows which were last to be filled. When the concrete in the rows first placed was well set the forms were removed and the stakes drawn by lever and chain. The holes were then carefully filled with grout and plastered before the remaining concrete in the upper layer was placed.

Between the two layers of concrete a half-inch plaster layer, previously mentioned, was placed, in order to provide a barrier impervious as possible to the flow of water. This layer was put down generally in strips about four feet wide and of any convenient length. The thickness was gaged by strips of wood one-half inch thick laid on the concrete, and the plaster brought level by a straight-edge. This coating was worked to a smooth, hard finish, similar to that on a granolithic walk and by the methods there employed. At first the proportions used were 1 part of Portland cement to 1 part sand, for the greater part of the layer, with a top finish of 4 parts cement to 1 part sand. Later, when cracks appeared, the proportion was changed to 1 part cement to 2 parts sand, and somewhat better results were obtained. Most of the cracks came where concrete laid at different times in the under layer was joined. These cracks were thoroughly washed with grout before being covered with the upper layer of concrete. For keeping the plastering wet, long strips of burlap were used. These were saturated with water and laid over the plaster as soon as it was hard enough to bear the weight. They formed an excellent covering, as they retained the

FIG. 1.—RESERVOIR LINING UNDER CONSTRUCTION: UNDER LAYER OF CONCRETE.

FIG. 2.—RESERVOIR LINING UNDER CONSTRUCTION: PLASTER WORK AND UPPER LAYER OF CONCRETE.

moisture for a long time and kept the direct rays of the sun from the work. The custom was to keep these coverings on the plaster for about two days and after that to keep it wet and cool by sprinkling. Beside the plaster between the layers of concrete, the upper edge of the concrete against the bank was also plastered as a precaution against infiltration of surface water and consequent damage by frost.

Before placing any mortar for plastering, the surface of the concrete layer was thoroughly swept with a heavy rattan stable broom, wet, again swept, and then moistened just before placing the mortar. It is thought that the plaster layer is thoroughly bonded to the concrete, and in several places where breaks ·ere made the plaster could not be removed separately, but both concrete and plaster came together.

The cost of the plaster work is found in Table No. 6. Three gangs, each consisting of a plasterer and helper, were employed on this work. The average amount of completed plas.er work per gang per day, under ordinary conditions, was about seven hundred square feet.

The concrete work in progress is shown in Plate III, Figs. 1 and 2, and the inside of the completed reservoir on Plate VI, Fig. 1.

After the banks were built a granolithic walk was constructed on top, entirely around the reservoir. This walk is six feet wide, and was laid in blocks about six feet long. It has a foundation about twelve inches thick of stones of various sizes up to about six inches in diameter. On top of this was spread about an inch of cinders or fine broken stone, which was thoroughly rolled and consolidated. The concrete layer resting on this foundation is four inches thick at the sides and an inch thicker in the middle. It was placed in one layer, mixed in the proportion of 1 part Portland cement, 3 parts sand, and 5 parts broken stone. Each block is separated from the one adjoining by a sand partition about three eighths of an inch thick. At first the concrete was put down in a continuous layer and then divided into blocks by pieces of steel about two feet long driven down through the layer. As it was almost impossible to get straight lines with these concrete knives, and as it was impracticable to lay the walk in alternate blocks on account of the width of the bank and the steep slopes, a method was devised of using templets between adjacent blocks. These were pieces of steel six feet long and three-eighths of an inch in thickness, curved on top

to the required arc of the surface of the finished walk. The only drawback observed with this method was the care necessary to be taken to avoid running the finishing tool over the top of the templet and thus neglecting the surface adjoining, in which case the top finish immediately against the iron would not be so thoroughly consolidated as other portions of the surface, and was liable to crack. On top of the concrete layer was placed the wearing surface one inch thick, which was composed of 1 part Portland cement and 1½ parts sand, with one pound of lampblack per barrel of cement to give the slate-colored appearance. After this layer had been thoroughly worked, the templets were removed, the space filled with sand, and a finishing tool for rounding off the edges run around the block. The cost of this work in detail is shown in Table No. 5.

The average gang employed on the granolithic walk, exclusive of the foundation, was six laborers and a single team on the concrete, and two masons and a tender on the finish coating. The average amount of walk finished per day was sixty linear feet, six feet wide.

The cost of the reservoir to the Commonwealth is shown in Table No. 9.

GATE CHAMBER.

As previously noted, this structure is located in the west bank of the reservoir. The front of the chamber, the steps leading to the top of the bank, and the sills for stop planks are of best quality Quincy granite. The tops of the sills, the treads of the steps, the coping and other trimmings are of six-cut dimension stone. The exposed portions of the front and wing walls are faced with ashlar of an average depth of ten inches, having edges pitched to a true, straight line. The stones were laid in Portland cement mortar, the proportions being 1 part cement to 2½ parts sand. On the dimension stone the joints were three-eighths inches thick and on the ashlar one-half inch, for a distance not less than six inches from the face. After laying, all joints were raked out and pointed with 1 to 1 Portland cement mortar. It was late in the fall and very cold when this was done. In order to work quickly the pointing mortar was mixed very wet, and consequently dripped over the faces of the stone, giving a very unsightly appearance.

Sectional Elevation.

Cross Section C-D.

Sectional Plan.

Cross Section E-F.

DETAILS OF GATE CHAMBER AND PIPE CONNECTIONS.

FIG. 3.

When work was resumed in the spring the matter of cleaning the stonework was greatly delayed, and when at last it was done, it was found necessary to entirely remove the pointing, wash the stone with acid, and repoint the joints. This work cost about fifty dollars. Men thoroughly accustomed to this kind of work were employed, as there was great danger of burning and thus spoiling the stone. Muriatic acid was used diluted with water in the proportion of 1 part acid to 2 parts water. This mixture was applied to the stone with paint brushes which had outlived their original usefulness. About four gallons of acid were used. Two men did the work, being employed five days removing the pointing, two days cleaning the stone, and two days repointing. About five hundred and sixty square yards of stone facing were gone over in this time.

Inside the gate chamber, above the level of the upper floor, the walls were lined with brick tied to the concrete backing with rows of headers. This work was left in the same condition as the stonework, and in the spring was given a coat of brick stain. This gave it an excellent appearance, and was less expensive and more satisfactory than cleaning with acid.

Except for the two floors, the woodwork in door and frame, and the ironwork in floor beams, wall castings, stop-plank grooves, etc., the remainder of this structure is of concrete.

The chamber is covered with Aberthaw sidewalk lights of standard construction. The top of this covering is on a level with, and forms a part of, the walk about the reservoir.

The gate chamber is divided vertically into two parts — an inlet and outlet chamber, and the gate chamber proper. The effective height of this structure is about twenty-two feet. In plan the water chamber is three by eleven feet and the gate chamber nine and one-half by eleven feet. This latter part is divided into three stories by two floors of six-inch hard pine, resting on Z-bars embedded in the concrete.

The piping and system of valves in the chamber is best explained by the sectional plans, Fig. 3. The main feed to the reservoir is through a twelve-inch by-pass from the twenty-four inch main. On the main, just beyond the by-pass branch and toward the reservoir, is a twenty-four inch gate valve, and beyond this a twenty-four inch check valve, so set as to open only when the head on the main falls below that in the reservoir. The reservoir is thus a storage basin, to be called on only in emergency. Between the check valve

and the water chamber is a sluice valve, and by shutting this and the twenty-four inch gate valve, the check valve can be readily overhauled.

In the bottom of the chamber is a twelve-inch pipe for draining the reservoir, into which the twelve-inch overflow pipe discharges. A closed gate on the drain on the reservoir side of the overflow pipe allows this pipe free discharge at all times. The overflow from the standpipe discharges into the reservoir freely, there being no valves on this line to be carelessly left closed. Flap valves are placed on the reservoir ends of both the drain and the by-pass from the twenty-four inch main, so that the valves on these pipes can be overhauled without drawing down the reservoir.

The inlet and outlet pipe from the gate house to the reservoir is thirty inches in diameter. This pipe is laid in a trench, dug through the undisturbed hard pan, and is surrounded by several concrete cut-off walls, well bonded into the sides of the trench.

Inside the chamber is a vertical pipe twelve inches in diameter, for a float gage. This pipe is connected with the water in the reservoir by a brass pipe, having a strainer on the reservoir end.

The actual cost of erecting the gate chamber is shown in Table No. 7, and its total cost to the Commonwealth is shown in Table No. 9.

A front elevation of the completed gate chamber is shown on Plate II, Fig. 2.

Table No. 7.

GATE CHAMBER — COST.

The Commonwealth furnished valves, pipes, specials, iron work, screens, and stop planks. Excluding the cost of these, but including the expense of setting the wall castings, the actual cost of the gate chamber was: —

Earth excavation	630 cu. yds.,	@ $ .944		$ 594.72
Concrete masonry, Class "A"	243 ,,	@ 6.820		1 657.26
Concrete masonry, Class "B"	37 ,,	@ 5.340		197.58
Granite Masonry.				
Stone delivered on work			$1 000.00	
Cement (estimated)	8 bbls.,	@ $2.23	17.84	
Sand (estimated)	3 cu. yds.,	@ 1.13	3.39	
Labor			168.68	
Rent of derrick	5 weeks		50.00	
Repointing and cleaning			50.00	
			———	1 289.91

Brick Masonry.

Labor		$60.90	
Brick	3 500, @ $10.00 per M.,	35.00	
Cement (estimated)	10 bbls., @ $2.23	22.30	
Sand (estimated)	4 cu. yds., @ 1.13	4.52	
			$122.72

Woodwork and Covering.

Aberthaw covering	132 sq. ft., @ $1.50	$198.00	
Door and frame		30.00	
Hard pine lumber in floors		25.00	
Hardware		10.00	
Labor		38.00	
			$301.00
			$4 163.19

STANDPIPE.

On July 17, 1900, the following bids for building the standpipe were received, and the contract was awarded to the lowest bidder, Walsh's Holyoke Steam Boiler Works, of Holyoke, Mass.: —

Canvass of Bids for Building Standpipe.

Bidders.	Amount.	Cost per Net Pound.
Walsh's Holyoke Steam Boiler Works, Holyoke	$4 425.00	$0.038
E. Hodge & Co., East Boston	4 498.00	.039
Edw. Kendall & Co., Cambridge	5 989.00	.051
R. D. Wood & Co., Philadelphia	6 720.00	.078

The following details relate to materials and methods of construction as provided in the specifications: —

The standpipe is cylindrical, 30 feet in diameter and 64 feet 4 inches high. It consists of a bottom of plates, and sides composed of thirteen courses of plates, each course, except the last, being five feet in height. Each course is of the same diameter at its top and bottom, and each alternate course is built inside those immediately above and below it, the inside radius of the lowest course and the outside radius of the next above it being each fifteen feet.

The bottom plates are three-eighths of an inch thick. In the vertical courses the plates have the following thicknesses : —

Lowest course	$\frac{9}{16}$ inch.	6th and 7th courses	$\frac{3}{8}$ inch.
2d and 3d courses	$\frac{1}{2}$ „	8th and 9th „	$\frac{5}{16}$ „
4th and 5th „	$\frac{7}{16}$ „	10th to 13th „	$\frac{1}{4}$ „

The lowest course is connected to the bottom on the inside by a $3\frac{1}{2}$ x $3\frac{1}{2}$ x $\frac{1}{2}$ inch angle, and the top course is stiffened by a 4 x 3 x $\frac{3}{8}$ inch angle inside. The bottom angle has closely butting joints, none of which come within twelve inches of any joint in bottom or side plates. The plates are of open hearth steel, containing not more than 0.06 per cent. of phosphorus, and having an ultimate tensile strength of not less than 54 000 nor more than 62 000 pounds per square inch; an elastic limit of not less than one half the ultimate strength; an elongation of not less than 26 per cent. in eight inches, and a reduction of area not less than 50 per cent. at fracture. The steel was to admit of bending cold, flat upon itself without fracture, both before and after being heated cherry-red and quenched in water. Provision was also made for such other tests as might be necessary. Laminations in plates or rolled shapes were sufficient cause for rejection, and plates were required to be free from slag, scale scabs, etc. No plate was to be deficient in weight more than two per cent. of the weight due the specified thickness, on a basis of forty-one pounds per square foot for plates one inch thick, and no part of any plate was to be one thirty-second of an inch below the required thickness.

The rivets are of best quality rivet steel and are all machine driven, except those in inaccessible locations and a very few which were driven while the pneumatic machines were out of order. Each course is composed of eight plates, and the joints in each course break at least three feet.. The vertical joints in the five lowest courses have outside butt-straps, while in the remaining eight courses these joints are lapped. All the vertical butt-straps have two rows of rivets on each side of the joint. The vertical joints in the sixth to the ninth courses inclusive are double riveted, and those in the remaining courses single riveted. The horizontal girth joints are lapped and single riveted, and the joints in the bottom are made with inside butt-straps with one row of rivets on each side of the joint. The size and pitch of the rivets in the several courses, in inches, is shown below.

	Horizontal Joints.			Vertical Joints.			Notes.
	Size.	Pitch.	Width Lap.	Size.	Pitch.	Width Lap.	
Bottom plates	3/4	2 1/8	6 1/2	. .	. .	. . .	In the bottom plates and in the vertical joints, in courses 1 to 5 inclusive, the width of lap is the total width of the cover plate for butt-joints — in all other cases it is the lap of one plate on the one adjacent. All dimensions are in inches. The thickness of the cover plates was the same as that of adjoining plates in tank.
Bottom angle	7/8	2 3/8	. . .	. .	. .	. . .	
1st course . .	7/8	2 3/8	3 1/2	7/8	2 7/8	10 3/4	
2d " . .	7/8	2 3/8	3 1/8	7/8	2 7/8	10 1/4	
3d " . .	7/8	2 3/8	3	7/8	2 7/8	10 1/4	
4th " . .	7/8	2 3/8	2 7/8	3/4	2 3/4	9 1/4	
5th " . .	3/4	2 1/8	2 3/4	3/4	2 3/4	9 1/4	
6th " . .	3/4	2 1/8	2 5/8	3/4	2 5/8	4 1/4	
7th " . .	3/4	2 1/8	2 1/2	3/4	2 5/8	4 1/4	
8th " . .	3/4	2 1/8	2 3/8	5/8	2 5/8	4	
9th " . .	5/8	1 15/16	2 1/4	5/8	2 5/8	4	
10th " . .	5/8	1 15/16	2 1/8	5/8	1 15/16	2	
11th " . .	5/8	1 15/16	2	5/8	1 15/16	2	
12th " . .	5/8	1 15/16	2	5/8	1 15/16	2	
13th " . .	5/8	1 15/16	2	5/8	1 15/16	2	
Top angle . .	3/4	4	3	. .	. .	. . .	

All calking edges were beveled by a planer, at least one-fourth inch of metal being removed. All shaping was done by cold rolling, no heating and hammering being allowed. No work was done below a blue or black heat, scarfing being only allowed in the upper eight courses, and the parts scarfed afterwards being thoroughly annealed. All eccentricity in rivet holes greater than one thirty-second of an inch was reamed, the use of a drift-pin to force the holes to coincide not being allowed.

The bottom of the tank is fitted with openings for the inlet and outlet pipe and a drain pipe. At the top there is a connection for the overflow pipe. For details see Fig. 4.

All shop work was done at the boiler works at Holyoke, and the parts were shipped to the work ready for erection, which was begun October 15. The concrete foundation for the standpipe was all ready (see Fig. 5), having been constructed by the contractors for the reservoir, as previously noted. On this foundation, and resting on rivet kegs directly over its final location, the bottom and first course of vertical plates were riveted together, and the inside seams

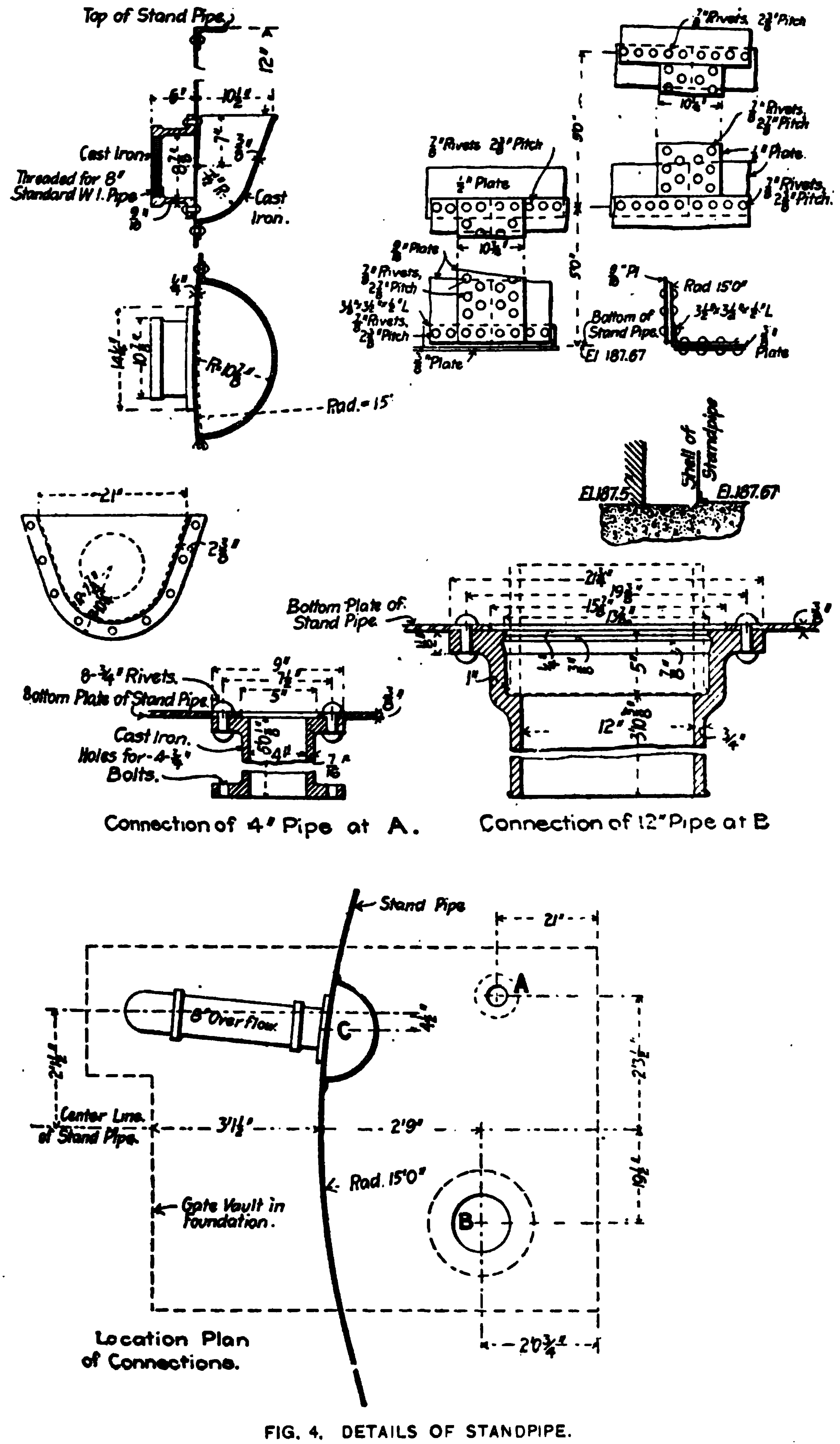
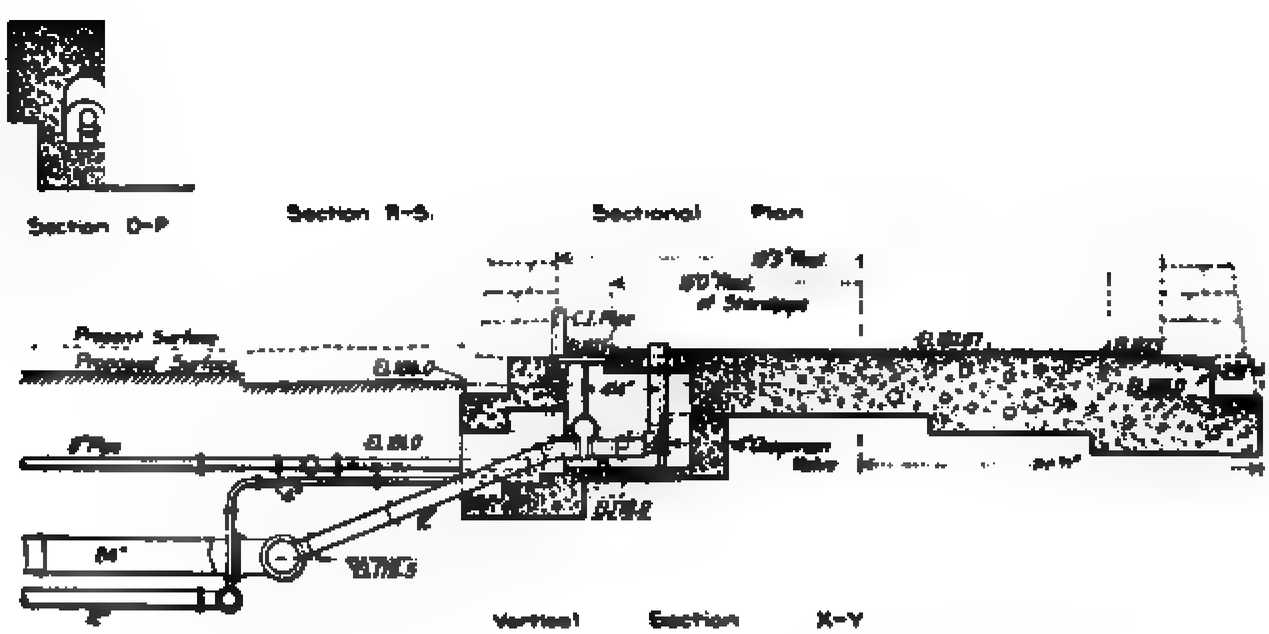


FIG. 4. DETAILS OF STANDPIPE.

calked (see Plate IV, Fig. 1). The bottom was then covered with water to the depth of the angle iron — about three and one-half inches — and the under side carefully examined for leaks. One or two damp spots were found, and after the water was drawn off these places



DETAILS OF FOUNDATION FOR STAND-PIPE AND MASONRY TOWER

FIG. 5.

were recalked. This portion was then lowered by hydraulic jacks and blocking to the concrete foundation.

The work of putting together the remainder of the plates was then begun. It was provided in the specifications that water might be ad-

PLATE IV.

FIG. 1.—RIVETING BOTTOM OF STANDPIPE.

FIG. 2.—STANDPIPE PARTIALLY ERECTED.

mitted and a floating platform be used for erection. The contractor, however, preferred to use inside and outside platforms swinging from the top of the last plates set up, and for hoisting the plates he used a gin-pole bolted to seams in this course. This pole was of such length that a block at its top would be about nine feet above the top of the course to which the pole was bolted. The hoisting rope passed through a movable block, in which was the hook carrying the plate to be raised, through the stationary block at the top of the pole, down to another block temporarily fastened about five feet above the bottom of the tank, across the tank to a block permanently fastened directly opposite the manhole, through which the rope passed to a winch operated by hand. The method of erection and the partially completed tank are shown on Plate IV, Fig 2.

The riveting and calking, except for some special reason, were all done by pneumatic machines. Power was furnished by a twenty-five horse power boiler, carrying a steam pressure of eighty pounds, and a twelve horse-power Clayton Air Compressor, furnishing a pressure of from one hundred to one hundred and ten pounds per square inch.

All the calking was done by a hand machine, using a round-nosed tool. The tendency was to use a thin tool and just upset the calking edge of the plate or strap. The method required was to use a tool with a thicker edge, starting it at about the middle of the plate edge and working here until the inner portion of this edge was driven against the other plate. The calking proceeded much slower by this method, but much tighter and more permanent joints were obtained.

For driving the rivets hand machines were used almost entirely, using a dolly bar to drive against. It had been intended to use a larger and more powerful tool, called a "gap riveter," hanging from a frame resting on top of the plates as erected. This machine did not work satisfactorily and was soon abandoned. If this machine had been used, it was planned to keep the rivet work just behind the erection of the plates, working up from the bottom. On account of not using the "gap riveter," and also on account of repairing the air compressor, which gave continual trouble,— not being large enough for the work,— it was decided to set up all the plates with bolts and then do the riveting, beginning at the top and working down.

The erection was finished November 20, all riveting and calking was done December 13, and the painting was finished a few days later.

After the work was done the tank was filled with water to a depth

of about six feet. The bottom of the tank was now resting on the rivet heads on top of the concrete foundation. The space between the bottom plate and the top of the concrete at the edge of the tank was calked tightly with gasket such as is used in pipe joints. Three by four inch grooves had been left in the top of the concrete foundation for use in pumping cement grout under the tank. The openings to all of these grooves except one were tightly closed with wooden plugs, and by means of a pump the grout was forced under the tank through this opening until it appeared at all of the other openings when the plugs were removed. The pump was then attached to each opening in turn and grout forced in until further pressure forced out the gasket near the opening. About fifteen barrels of Portland cement were used on this work.

After this was done the standpipe was filled with water, and several places on the sides where leaks appeared were calked. Several leaks about the bottom gave the most trouble, and it was necessary to draw off the water and do some inside calking before they could be stopped. On filling the tank again only a dripping was apparent about the bottom, and by the next spring this had stopped, and the tank is now apparently water-tight.

The cost of the work is shown in Tables Nos. 8 and 9.

Table No. 8.

COST OF FURNISHING MATERIAL AND ERECTING STANDPIPE, 1900.

Labor.			
Assembling plates	$383.33		
Riveting	488.38		
Calking	111.95		
Painting	47.36		
Cost	$1 031.02	Cost per lb.	$ .00885
Materials.			
55 tons steel plate, @ $50.00	$2 750.00		
1 ton L iron	107.00		
70 kegs rivets, @ $2.75	192.50		
Bolts used in erection	10.00		
Moving material to and from shop and cars	250.00		
Freight on material	180.00		
Cost	$3 489.50	Cost per lb.	.02996
Total cost	$4 520.52	Total cost per lb.,	$ .03881
Estimated cost of field plant			$1 600.00

Force employed and rate, —

1 foreman, @ $3.50; 1 calker, @ $3.00; 1 riveter, @ $2.50; 1 engineer, @ $2.50; 2 heaters, @ $2.00; 3 helpers, @ $1.80.

Table No. 9.

COST OF WORK TO COMMONWEALTH OF MASSACHUSETTS.

(To January 1, 1902.)

Reservoir.			
Earth excavation, 30 100 cu. yds.		$11 438.00	
Rock excavation		52.00	
Concrete masonry		15 044.50	
Plastering		1 705.60	
Granolithic walk		1 313.17	
Seeding		21.00	
Railing and labor		425.75	
Miscellaneous: plastering, grading, etc., extra		461.54	
			$30 461.56
Gate Chamber.			
Earth excavation, 630 cu. yds.		$ 239.40	
Concrete masonry		2 232.00	
Granite masonry		855.20	
Brick masonry		115.56	
Pipe connections — labor		100.00	
Woodwork and covering of gate chamber		480.00	
Laying water pipes, 30″ and 24″		29.90	
Furnishing water pipes, 30″, 24″, 12″, and 12″ drain		487.09	
Valves		1 289.09	
Specials and wall castings		508.80	
Stop-planks, screens, float gage, etc.		253.02	
Iron work: beams, ladders, M. H. frames and covers, etc.		310.00	
Lead, freight, etc.		55.34	
Labor: laying drain, teaming pipe, etc., extra		761.71	
Extra on stonework, recutting steps		47.28	
			7 764.39
Standpipe.			
Foundation.			
Excavation, 1 355 cu. yds.	$514.90		
Concrete masonry	1 704.00		
Grouting under standpipe	133.26		
		$2 352.16	
Pipe Connections.			
Furnishing 4″, 8″, and 12″ cast-iron pipe	$111.80		
Labor	20.00		
Specials and valves	207.57		
		339.37	
Standpipe, furnishing and erecting (Walsh contract)		4 529.72	
Masonry tower (McCoy contract), to January 1, 1902		11 774.05	
			18 995.30
Miscellaneous.			
Extension of Section 21 of pipe line.			
Pipe trench excavation, 249 cu. yds.		$94.62	
Laying 24″ pipe		44.91	
24″ valve, frame and cover for M. H.		237.82	
Furnishing 24″ pipe		293.78	
General expense: fence, rent of land, spur track, etc.		492.54	
Driveway (unfinished), to January 1, 1902		62.20	
Extra work: grading land, disposal of surplus, driveways, etc.		603.08	
			1 828.95
Total cost to January 1, 1902			$59 050.20

MASONRY TOWER.

The bids for building the masonry tower about the standpipe were opened May 14, 1901, and on May 23 the contract for furnishing all the materials and doing all the work was awarded to the lowest bidder, Mr. J. E. McCoy, of Boston.

The canvass of bids received for this work was: —

Bidders.	*Amount.*
John Carlman, Quincy	$31 000.00
Fessenden & Libby, Boston	30 500.00
James H. Jacobs, Boston	24 973.00
James E. McCoy, Boston	24 790.00

The following are the principal items included in this work, as estimated from the drawings: —

Rubble stone masonry	925 cu. yds.
Dimension stone masonry	275 ,,
Iron and steel Work	14 tons
Granolithic observation roof	90 sq. yds.

The plans, sections, and elevations of this work are shown on Figs. 6 and 7.

The tower is about seventy-seven feet high from the surface of the ground to the top of the caps of the merlons. The inside of the wall is plumb, while the outside face has such a batter that the thickness of the wall is four and three-quarters feet at the top of the standpipe foundation, three and five-tenths feet at a point nine and five-tenths feet above this foundation, and two feet just below the cornice arches. The merlon caps and embrasure sills are the largest and heaviest stones used. There are sixteen each of these, and each stone weighs about three and one-half tons.

Beside its general design, the principal architectural feature of the tower is the arch over the entrance (Plate V, Fig. 2). This has a clear span of eight feet five inches, and a rise equal to one half the span. Its face is curved and battered to conform with the outside surface of the wall, and in this respect presents a form of arch not frequently encountered. In the drawings the joints of the several arch stones were laid out to be cut on planes normal to the vertical plane of projection of the arch rather than on planes radiating from the center of the tower. On account of the curved surface horizontally and the batter vertically, this was thought the easiest way of cutting

PLATE V.

FIG. 1.—MASONRY TOWER DURING ERECTION.

FIG. 2.—ENTRANCE TO MASONRY TOWER.

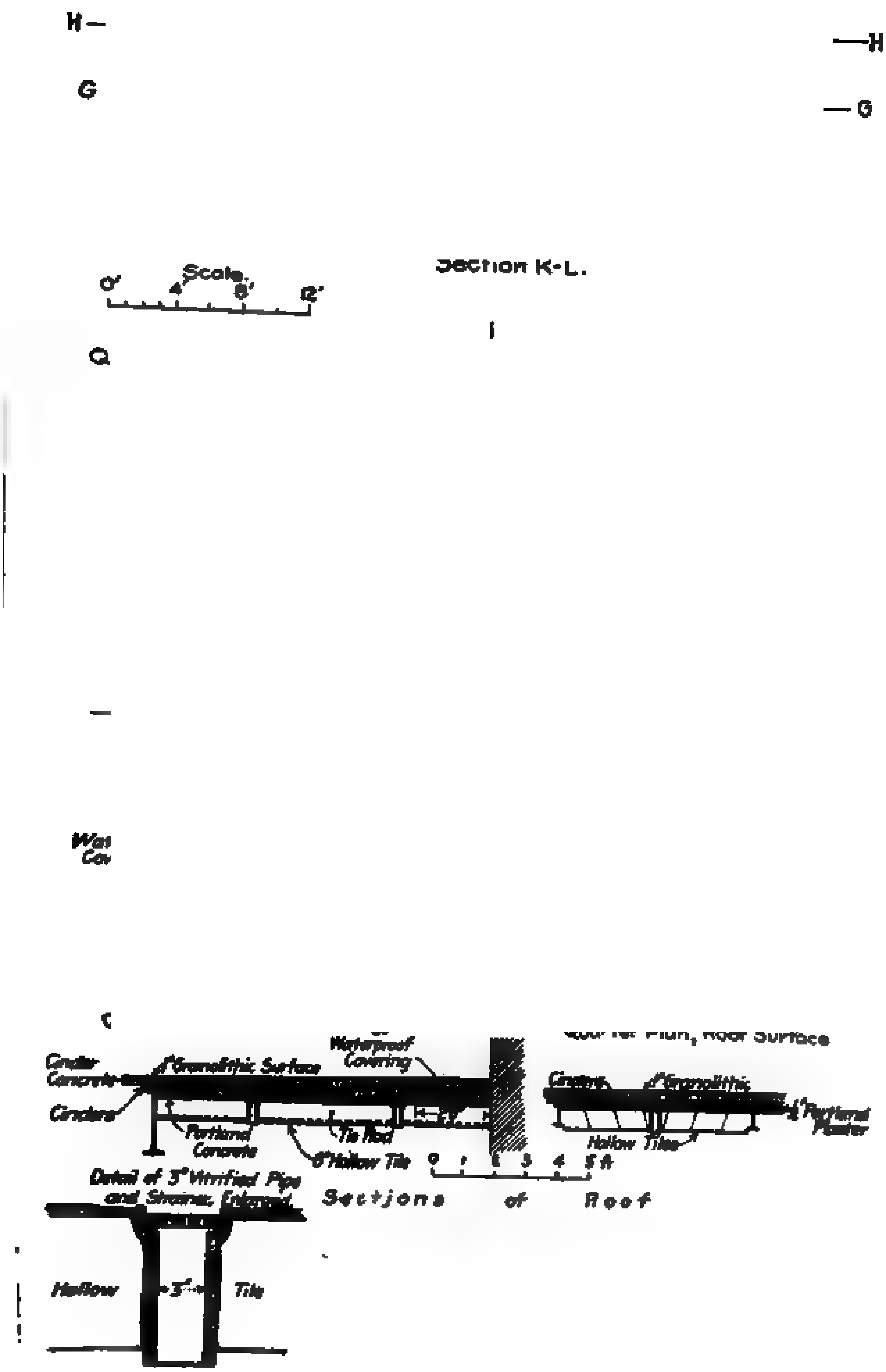


FIG 6. DETAILS OF MASONRY TOWER.

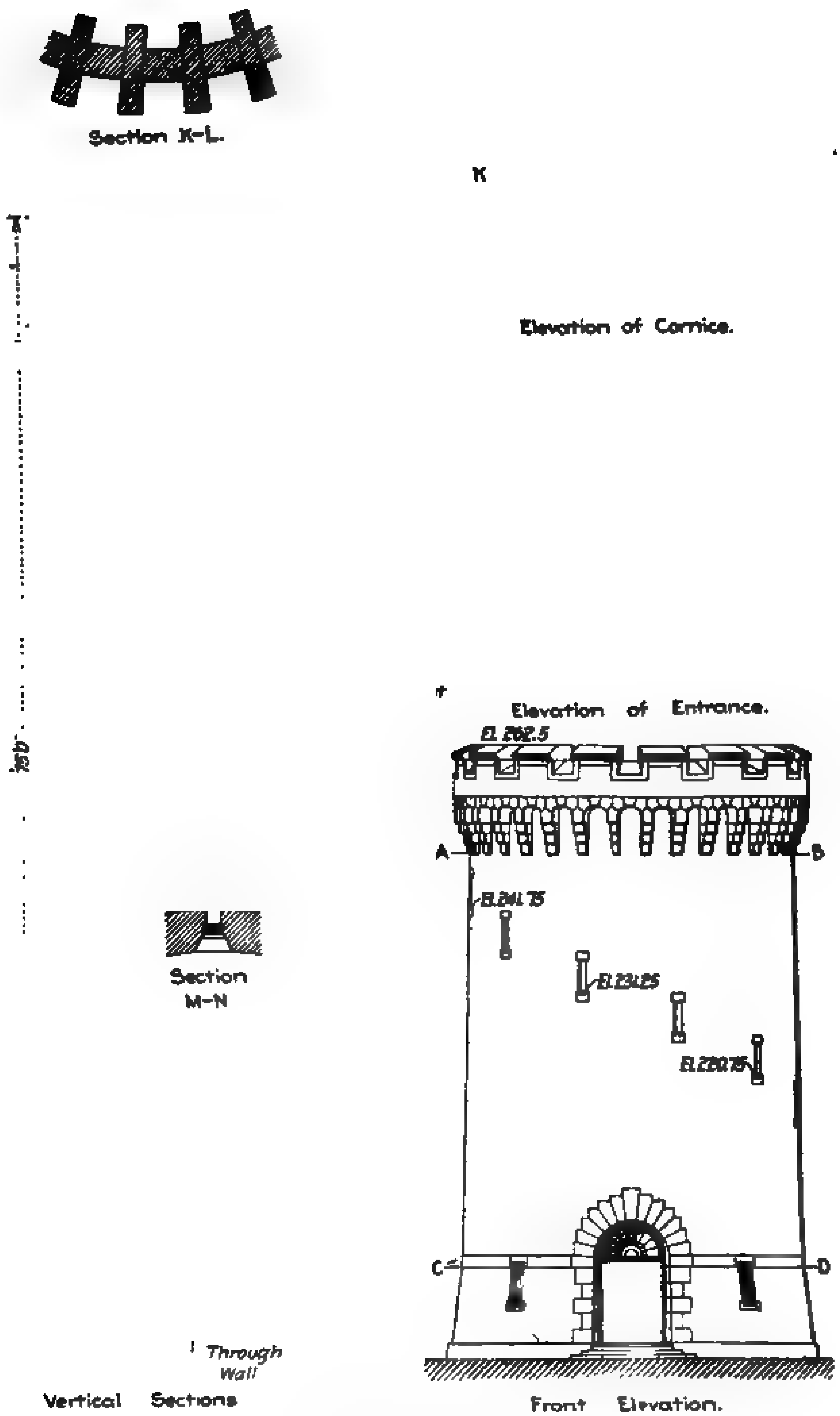


FIG. 7. MASONRY TOWER.

the stone, since it allowed the joints to be cut as though the arch were in a plane wall, after which the faces could be cut to curve and batter. Considerable difficulty was encountered, however, in cutting these stones, and it was found best to rough them out as nearly as possible, try them temporarily in their places in the arch, resting on the centering, and finally trim them to proper shape. This method would have been unnecessary if the foreman stonecutter had given proper attention to the work, as the plans were perfectly clear in this respect.

The contractor commenced work on May 27. Two forty-foot boom derricks, operated by hand, were set up and used until the wall was about ten feet high. They were first set up on the south side of the tower, moved around to the north side as the work progressed, and finally removed altogether. Between the outside of the standpipe and the inside of the masonry wall is a space three feet three inches wide, in which will finally be placed a circular stairway leading to the observation roof. In this space the contractor at once began to erect a wooden staging and working platforms. Pairs of uprights three feet three inches outside to outside, with one side resting against the plates, were spaced about six feet apart around the tank. These were of three by four spruce stock except at two places directly opposite each other, where they were of hard pine, those next the tank being six by eight and those outside being four by six spruce. These uprights were thoroughly cross braced, and when the staging was completed two wire ropes were passed around the tower outside the inner row of uprights and, when tightened by turnbuckles, bound the staging firmly to the tank. When the staging was finished two pairs of four by twelve hard pine timbers, six feet on centers and thirty feet long, trussed with one and one-fourth inch steel rods, were placed across the top of the tank, resting partly on the sides of the tank and partly on the six by eight hard pine uprights and other portions of the staging. On these trusses and on other timbers resting on the top of the tank, a plank platform was built and covered with sailcloth to prevent dirt and stones from falling into the tank. Until the wall was built nearly to the top of the tower the tank was kept almost full of water, to afford as much stability as possible. On top of the platform between the trusses and over the center of the tank and tower the derrick was placed with which the larger part of the stone was handled. This derrick had a thirty-foot boom and a twenty-foot mast. It was held in place by six five-eighths-inch wire

guys, anchored to fourteen by fourteen inch hard-pine uprights and deadmen from three hundred to four hundred feet distant from the tower.

This derrick was operated by a twelve horse-power double-drum engine, set on the ground about sixty feet south of the tower. Single iron blocks ten inches in diameter with one-half inch wire falls were used until the big stones for the top were to be raised, when a two-part block was substituted on the boom. This derrick was pivoted so that it could swing all about the tower, but, on account of the leaders to the engine, could not make a second revolution in the same direction. The staging and partially completed wall are shown on Plate V, Fig. 1.

The following description, partially abstracted from the specifications, gives a general idea of the character of the work: —

The cement, sand, and concrete conformed to the requirements of first-class work. Except as otherwise stated, uncoursed rubble masonry laid in natural cement mortar, mixed in the proportion of 1 part cement to 2 parts sand by measure, was used for the wall of the tower. The stones in this portion of the work were of sound, clean, Quincy granite "grout," from which thin edges and large projections had been removed. Headers constituted about one fourth the area of the outside face, and were of sufficient size to secure a strong bond with the rest of the masonry. The exterior of the tower, the interior above the roof, and a band about eight feet wide following the wind of the stairs were laid to such a face that no stone projects more than two inches beyond the neat lines. In the remainder of the work no stone projects nearer to the tank than three feet. In the rubble work the stones were all roughly dressed to lay with joints on the face averaging three fourths of an inch, great care being taken to break joints in the several courses. Very few stones were used having a face area less than one square foot, and the least depth of bed for the face stones was limited to six inches, the length of bed being twice the rise for stones having a rise of less than twelve inches. The steps at the entrance, the base course, voussoirs of all arches, the quoins of the entrance, the sills and lintels of all windows, the belt course at the top of the lower windows, the corbels carrying the cornice arches, the sills of the embrasures, the caps of the merlons, and the band under the caps were of best quality Quincy or Rockport granite. The bed joints of these stones were dressed for six inches from the face and laid with a

FIG. 1. — INSIDE OF COMPLETED RESERVOIR.

FIG. 2. — RESERVOIR AND MASONRY WATER TOWER.

joint not exceeding one-half inch for this distance, and a limit of three inches for the remainder of the joint, except in the case of the radial joints of the voussoirs, where no portion of the joint exceeded one inch in thickness.

The dimension stones were laid with the same quality of mortar as used in other parts of the work. The exposed faces of the steps, the washes and tops of the sills and bottoms of the lintels of the large windows were six-cut, the faces of the sills and lintels of the small windows rock-faced, and the remainder of the dimension stone either rough or fine pointed. The roof framing consists of steel beams, channels, and plates fitted and framed together. At the main entrance there are boiler iron doors stiffened with angle irons, studded with rivets, and hung on forged hinges. The stair carriages consist of five-sixteenths by eight inch plates and three by five inch angles thoroughly braced and anchored to the wall. The treads and landings are to be cast and have suitable pattern work on the top surface. The railings and stanchions are to be of wrought-iron pipe. All iron-work is to be of the best quality, and the workmanship first-class in every respect.

An eight-inch overflow pipe from the top of the standpipe and a three-inch drain pipe from the roof, both of wrought iron, are carried down to the vault in the foundation in a chase left in the wall for this purpose. The lower windows and transom over the door are to be protected with suitable wrought-iron grilles.

The roof is to be composed of eight-inch terra-cotta flat arches, "end construction," covered with Portland cement concrete mixed 1 part cement, 2 parts sand, and 5 parts fine gravel. On top of the concrete is to be placed a one-fourth inch coat of neat Portland cement mortar, thoroughly troweled and floated to make a water-tight surface which shall pitch evenly to drainage points. Over this plastering a water-proof covering, two feet six inches wide, consisting of four layers of twenty-five pound saturated felt lapped three inches and cemented with hot pitch, is to be laid around the roof next the wall. This is to be flashed with five-pound lead let into the joints in the wall. On top of the plaster surface and water-proof layer is to be spread a thin layer of clean cinders and on top of this a concrete layer about three inches thick, finished with a granolithic wearing surface sloping to a drain in the center of the roof. The intention is, that if the granolithic surface of the roof cracks, water will not lodge under and in the concrete, and, then freezing, do serious damage ; but will filter

through the cinder layer and thence into the tank. This, of course, will be only in very small quantities, as the bulk of the water falling on the roof will be discharged by the drain outside the tank.

The upper portion of the stairs and the landing on the roof are to be covered with a wooden hood, the exposed portions of which are to be of best quality hard pine. Iron brackets about six feet apart have been let into the stonework on the inside of the tower about three feet below the top of the standpipe to carry a platform to give access to all parts of the top of the tank. In the roof two hatchways with iron frames and covers are placed, to give light and facilitate entrance for work inside the tank.

On account of delay in receiving the cut stone, the progress has been very slow. However, with the exception of the steps at the entrance and the cleaning and pointing, this portion of the work is now finished. The completed tower is shown in Plate VI, Fig. 2, and the detail of the entrance in Plate V, Fig. 2.

The average force employed per day during the time when the stonework was well under way was, one foreman, one engineer, five stonecutters, one blacksmith, two tag men, three tenders, two drillers, and nine masons; — in all, twenty-four men.

The dimension stone was supposed to be delivered on the work ready to be placed, but all the entrance arch stones and many of the others were brought to the work in the rough and cut on the ground. Beside these many of the other stones required some trimming, and some had to be entirely recut.

After freezing weather came, Portland cement was substituted for the natural cement previously used, and the proportion changed to 1 part cement and 3 parts sand. At this time also all materials for the mortar were heated, and the freshly laid masonry protected as well as possible.

COST OF WORK.

The several tables show the cost of the work and the quantities of materials used and handled except on the masonry tower, which is not yet completed. All data of cost except those in Table No. 9 are *actual* costs to the contractor, estimated from the force accounts and notes kept by employees of the Metropolitan Water and Sewerage Board. Table No. 9 is compiled from payments made by the Commonwealth on account of the work herein described.

All elevations given either in the text or on the plates are referred to Boston City base, which is approximately the elevation of mean low water in Boston Harbor.

WATER WORKS STATISTICS FOR THE YEAR 1901, IN FORM ADOPTED BY THE NEW ENGLAND WATER WORKS ASSOCIATION.

COMPILED BY CHARLES W. SHERMAN, EDITOR, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

The following tables of statistics contain more or less complete statistics for forty water works, which have used, more or less closely, the form adopted by the Association for summarizing statistics. Some of these works report under very few of the headings of the summary.

The Editor has made no attempt to compile statistics from water-works reports which do not include at least a partial summary.

The report of the Committee on Uniform Statistics, containing the form as endorsed for use in the 1901 reports, is printed on page 51 of this volume of the JOURNAL (March, 1902).

Previous compilations of statistics may be found in the JOURNAL, as follows: —

Statistics for	*Reference to Journal.*
1886	Vol. I, No. 4, p. 29
1887	Vol. II, No. 4, p. 28
1888 to 1892 inclusive	Vol. VII, p. 225
1893	Vol. IX, p. 127
1894	Vol. X, p. 131
1895–96	Vol. XII, p. 273
1897–99	Vol. XV, p. 65
1900	Vol. XV, p. 367

1901.—TABLE 1.—GENERAL AND PUMPING STATISTICS.

2	Attleboro, Mass. .	1873	Town.	Well near Seven Mile River.	Pumping.	Deane, Barr.	Bitu. Coal.		. .	. .	. .
3	Bay City, Mich. .	1872	City.	Saginaw Bay.	Pumping.	Holly.	Bitu. Coal.		1 42	. .	$0 50
4	Billerica, Mass. . .	1898	Town.	Driven Wells.	Pumping.	Barr.	Bitu. Coal.		4 70	. .	. .
5	Brockton, Mass. .	1880	City.	Salisbury Brook.	Pumping.	Worthington, Barr.	Bitu. Coal.		5 14	8.8	. .
6	Burlington, Vt. .	1867	City.	Lake (	Pumping.	Worthington.	Bitu. Coal.		4 05	. .	. .
7	Cambridge, Mass. .	1855	City.	Ston Hob Fres	Pumping.	Leavitt, Worthington, Blake.	Bitu. Coal.		4 08	. .	. .
8	Chelsea, Mass. . .	1867	City.	Metro		. . .	. . .		. .	. .	. .
9	Concord, N. H. .	1872	City.	Penacook Lake.	Gravity and Pumping.	. . .	Bitu. Coal.		. .	. .	. .
10	Fall River, Mass. .	1874	City.	Watuppa Lake.	Pumping.	Worthington, Davidson.	Bitu. Coal.		. .	. .	. .
11	Fitchburg, Mass. .	1878	City.	Storage Reservoirs.	Gravity.	. . .	. . .		. .	. .	. .
12	Freeport, Me. . .	1891	Private Owner.	Brook and Springs.	Pumping.	Deane.	Bitu. Coal.	New River.	3 50	. .	2 50
13	Holyoke, Mass. . .	1873	City.	Lakes and Streams.	Gravity.	. . .	. . .	. . .	. .	. .	. .
14	Lowell, Mass. . .	[illegible]	City.	Driven Wells.	Pumping.	Morris, Worthington, Deane, Knowles.	Bitu. Coal.	Cumberl'd.	4 70	. .	. .
15	Lynn, Mass. . . .	1870	City.	Brooks and Saugus River.	Pumping.	Morris, Loretz.	Bitu. Coal.	Georges Cr.	. .	. .	. .

16	Maynard, Mass. .	1880	Town.	White Pond.	Pumping.	Blake.	Bitu. Coal.	Georges Cr.	$4 65	20.	. .
						Chestnut	*Hill High*	*Service*	*Station.*		
						Holly, Quintard Iron Works, Allis.	Bitu. Coal. Anth. Coal.	Georges Creek, Loyal Hanna. Screen'gs.	4 29	9.2	. .
17	Metropolitan Water Works, Mass. .	1848 1872 1895	State of Massachusetts.	Lake Cochituate, Sudbury River, Nashua River.	Pumping.	*Chestnut*	*Hill Low*	*Service*	*Station.*		
						Holly.	Bitu. Coal.	Loyal Hanna.	4 44	8.9	. .
						Spot	*Pond*	*Station.*			
						Blake, Holly.	Bitu. Coal. Anth. Coal.	Georges Cr. Screenings.	4 41	9.7	. .
18	Middleboro, Mass.	1885	Fire Dist.	Well.	Pumping.	Deane.	Bitu. Coal.	Pocahontas, Cumberland.	4 70	. .	. .
19	Minneapolis, Minn.	1868	City.	Mississippi River.	Pumping.	Hardenburg, Waters, Pray, Strothman, Worthington, Holly.	Sawdust, Edgings, etc., and some Coal.	. . .	. .	. .	(1)
20	New Bedford, Mass.	1866 1895	City.	Quittacas Ponds.	Pumping.	Quintard, Worthington, Dickson Mfg. Co.	Bitu. Coal.	Pocahontas.	4 95	7.	$4 00
21	New London, Conn.	1872	City.	Lake Konomoc.	Gravity.	. . .	. . .	. . .	. .	. .	. .
22	Newton, Mass. . .	1876	City.	Collecting Gallery.	Pumping.	Blake, Worthington.	Bitu. Coal.	Georges Cr.	4 37	8.	6 00
23	Norwich, Conn. .	1868	City.	. . .	Gravity.	. . .	. . .	. . .	. .	. .	. .
24	Oberlin, Ohio . .	1887	Village.	East Branch of Vermilion River.	Pumping.	Deane.	Semi-Bitu.	Pocahontas.	3 70	. .	. .
25	Plymouth, Mass. .	1855	Town.	Great and Little South Ponds, Lout Pond.	Gravity and Pumping.	Worthington.	Bitu. Coal.	Various.	5 00	. .	. .

[1] Sawdust, $4.00 per million gallons pumped.

1901.—TABLE 1, *Continued.*—GENERAL AND PUMPING STATISTICS.

33	Taunton, Mass. .	1876	City.	Elder's and Assawompsett Pds.	Pumping.	Holly, Allis.	Bitu. Coal.	Cumberl'd.	4 25 4 75	12.5 9.5	. . . .
34	Waltham, Mass. .	1872	City.	Filter Basin near Charles River.	Pumping.	Barr, Worthington.	Bitu. Coal.	Georges Cr.	4 78	11.	. .
35	Ware, Mass. . . .	1886	Town.	Wells.	Pumping.	Dean.	Bitu. Coal.	Georges Cr.	4 83	. .	5 00
36	Wellesley, Mass. .	1884	Town.	Wells.	Pumping.	Blake.	Bitu. Coal.	Puritan.	4 08	9.9	3 50
37	Whitman, Mass. .	1888	Town.	Well.	Pumping.	Blake, Worthington.	. . . .	. . . .	. .	. .	. .
38	Winchendon, Mass.	1896	Town.	Well.	Pumping.	Blake.	Bitu. Coal.	Cumberl'd.	5 52	9.	. .

39	Woburn, Mass. .	1872	City.	Filter Gallery near Horn Pond.	Pumping.	Worthington, Blake.	Bitu. Coal.	Elk Garden, Georges Creek.	$4 41	9.	. .
40	Yonkers, N. Y. .	1874	City.	Streams and Tubular Wells.	Pumping.	Wright, Worthington, Camden.	Bitu. Coal.	Georges Cr.	3 85	. .	$10 00

1901.—TABLE 1, *Concluded.*—PUMPING STATISTICS.

	3	4	4a	5	6	7	8	9	10	11	12	13	14
Number.	Coal Consumed for the Year. (Lbs.)	Lbs. of Wood ÷ 3 = Equivalent Coal.	Amount of Other Fuel Used.	Total Equivalent Coal Consumed for the Year. (Lbs.) (3) + (4).	Total Pumpage for the Year in Gallons.	Average Static Head against which Pumps Work. (Feet.)	Average Dynamic Head against which Pumps Work. (Feet.)	Number of Gallons Pumped per Lb. of Equivalent Coal.	Duty in Foot-pounds per 100 Pounds of Coal. No Deductions.	Cost per Million Gallons pumped into Reservoir, figured on Pumping Station Expenses.	Cost per Million Gallons raised 1 Foot high, figured on Pumping Station Expenses.	Cost per Million Gallons pumped into Reservoir, figured on Total Maintenance (CC).	Cost per Million Gallons raised 1 Foot high, figured on Total Maintenance (CC).
1	3 401 615	5 000	. .	3 406 615	1 094 651 552	93	126 7	321	33 945 400	$ 8 81	$0 07	$ 82 57	$0 65
	1 276 978	3 000	. .	1 279 978	151 040 127	123 3	123 3	118	12 129 300	31 19	0 25		
2	498 200	. . .	. .	. . . .	147 946 520	. .	188 / 225	297	55 600 000	. . .	. . .	. . .	. . .
3	4 644 900	3 667	. .	4 648 567	1 082 691 511	. .	113	233	21 949 353	6 91	0 061	32 59	0 288
4	231 035	. .	. .	. . . .	21 946 359[1]	275	317 5	95	25 108 771	73 29	0 23	273 45	0 86
5	445 508	100	. .	445 608	443 938 118[1]	38	43	996	35 727 610	6 66	0 154	107 89	2 51
6	. . . .	. .	. .	. . . .	304 685 775	289	316	. .	. . . .	28 17	0 089	119 60	0 378
7	3 619 340	500	. .	3 619 840	2 785 156 440	158	194 4	769	124 770 490	5 40	0 028	28 45	0 146
9	301 716	. .	. .	. . . .	149 371 035	. .	. . .	495	. . . .	. . .	. . .	. . .	. . .
10	. . . .	. .	. .	. . . .	1 320 839 810	. .	185 8	323	. . . .	9 71	. . .	97 27	. . .
12	153 800	6 000	. .	159 800	18 045 000[1]	160	180	118	150 683 605	51 40	0 32	130 55	0 82
14	8 774 196[2]	2 400[2]	. .	3 767 596[2]	2 178 818 435[2]	156[2]	163 6[2]	577[2]	78 712 429[2]	8 11[2]	0 05[2]	. . .	. . .
15	40 400	. .	. .	. . . .	19 582 505	. .	165 5	484	66 809 779	7 02	0 042	85 10	0 500
	2 625 400	. .	. .	. . . .	1 624 680 750	. .	157 5	618	81 205 994				
16	299 778	. .	. .	299 778	54 884 545[1]	190	212	183	81 240 547	. . .	. . .	. . .	. . .
17	*Chestnut*	*Hill*	*High*	*Service*	*Station.*								
a	499 756	. .	. .	. . .	202 470 000	. .	124 3	608	65 760 000	10 63	0 086	. . .	. . .
b	310 069	. .	. .	. . .	204 510 000	. .	48 1	1 077	45 090 000	0 52	0 198	. . .	. . .
c	953 488	. .	. .	. . .	1 016 570 000	. .	125 3	1 102	118 600 000	4 36	0 035	. . .	. . .
d	482 009	. .	. .	. . .	645 580 000	. .	67 8	1 479	86 090 000	3 76	0 055	. . .	. . .
e	6 346 061	. .	. .	. . .	8 584 110 000	. .	126 3	1 353	144 450 000	3 17	0 025	. . .	. . .
	Chestnut	*Hill*	*Low*	*Service*	*Station.*								
f	8 528 670	. .	. .	. . .	26 854 400 000	. .	48 4	3 090	126 420 000	1 50	0 031	. . .	. . .
		Spot	*Pond*	*Station.*									
g	344 975	. .	. .	. . .	351 890 000	. .	114 5	1 020	99 320 000	5 45	0 048	. . .	. . .
h	2 076 021	. .	. .	. . .	2 414 530 000	. .	119 5	1 163	117 700 000	4 75	0 040	. . .	. . .

18	536 970	. .	. .	. . .	81 884 000[1]	182	203	152	25 796 680	$31 95	$0 157	$ 89 25	$0 44
19	1 485 716	. .	22 435	. . .	6 591 613 020	. .	. .	. .	72 887 614 / 74 842 026	. . .	. . .	. . .	. . .
	Little Quittacas Station.												
20	2 557 950	33	. .	2 557 983	2 086 593 318[4]	166 8	189 5	816	128 932 150	5 99	0 032	58 83	0 281
	Purchase Street Station.												
	182 050	33	. .	182 083	45 275 272[2]	184 4	192	348	54 899 943				
22	1 720 800	6 000	. .	1 726 800	673 803 875[3]	234	254	390	82 600 000	13 60	0 055	169 72	0 67
24	303 000	. .	. .	. . . .	40 374 000[4]	80	80	138	8 800 000	38 90	0 48	111 80	1 36
25	. . .	. .	. .	407 430	198 430 160	65	66	488	26 132 139	13 88	0 21	61 08	0 925
26	5 690 300	833	. .	5 691 133	3 891 304 283[4]	171 5	176 9	684	100 888 000	4 70	0 027	. . .	. . .
	280 500	4 750	. .	285 250	165 074 474[4]	171 5	177	579	85 441 200	(low serv.)			
	775 913	1 376	. .	777 289	476 290 901[4]	112 0	126 6	613	64 702 900	15 25	0 111	. . .	. . .
	121 159	206	. .	121 365	67 525 560[4]	111 1	112 6	556	52 253 800	(high serv.)			
28	481 469	. .	. .	. . . .	57 479 577[1]	219	240	119	23 892 917	47 00	0 196	265 95	1 10
29	2 123 310	1 200	. .	2 124 510	704 993 037[1]	212 8	252	331	69 741 717	8 82	0 035	92 71	0 368
33	1 122 019	. .	. .	1 122 019	631 214 244	. .	67 5	538	31 655 803	9 92	14 70	89 55	1 38
	403 000	. .	. .	403 000	504 135 478	. .	. .	. .	. . . .				
34	1 481 840	. .	. .	1 481 840	836 407 890[1]	164	180	. .	85 204 300	10 15	0 056	49 87	0 277
35	578 710	900	. .	579 610	116 793 885[1]	221	244	201	41 005 311	17 28	0 07	58 26	0 238
36	486 844	387	. .	487 231	88 975 417[1]	260	286	182	42 639 782	25 80	0 09	183 62	0 656
38	190 600	. .	. .	190 600	31 368 800[4]	240	280	198	45 660 004	25 28	0 093	198 56	0 709
39	1 522 200	. .	. .	1 522 200	426 638 100[1]	200	216	280	50 490 273	14 89	0 069	27 25	0 126
40	4 176 325	. .	. .	. . . .	1 272 378 811	185	. .	304	. . .	10 67	. . .	. . .	. . .

[1] Without allowance for slip. [2] Station No. 1 only. [3] Cords sawdust (1 cord assumed = 585.8 lbs. coal). [4] With allowance for slip.

a Engines Nos. 1 and 2. *b* Engines Nos. 1 and 2 (low service). *c* Engine No. 3. *d* Engine No. 3 (low service). *e* Engine No. 4. *f* Engines Nos. 5, 6, and 7. *g* Engine No. 8. *h* Engine No. 9.

1901.—TABLE 2.—FINANCIAL STATISTICS.—MAINTENANCE.

Number.	Name of City or Town.	Balance from Previous Year.	Receipts from Consumers.				
			A	B	C	D	E
			Fixture Rates.	Meter Rates.	Net Receipts for Water.	Miscellaneous Receipts.	Total Receipts from Consumers.
1	Atlantic City, N. J.	$ 2 794 19	. . .	. . .	$ 94 327 57	. . .	. . .
2	Attleboro, Mass.	. . .	. . .	. . .	27 325 34	$ 87 50	. . .
3	Bay City, Mich.	. . .	$ 9 639 43	$ 14 426 31	24 065 74	809 91	$ 24 875 65
4	Billerica, Mass.	. . .	1 357 61	1 427 32	2 784 93	48 21	2 833 14
5	Brockton, Mass.	. . .	8 154 02	62 209 14	70 363 16	6 707 39	77 070 55
6	Burlington, Vt.	. . .	9 001 93	38 829 60	47 831 53	1 354 21	49 185 74
7	Cambridge, Mass.	. . .	213 493 04	109 380 25	322 873 29	. . .	329 224 47
8	Chelsea, Mass.	. . .	62 240 46	19 709 60	81 950 06	2 618 33	84 568 39
9	Concord, N. H.	. . .	30 240 99	31 762 73	62 172 56	155 42	62 327 98
10	Fall River, Mass.	30 512 97	3 946 07	159 057 74	. . .	. . .	168 084 17
11	Fitchburg, Mass.	. . .	22 357 29	43 170 61	. . .	. . .	60 035 38
12	Freeport, Me.	. . .	2 000 00	0	2 000 00	. . .	2 000 00
13	Holyoke, Mass.	25 584 08	71 603 37	15 767 70	87 371 07	. . .	. . .
15	Lynn, Mass.	. . .	. . .	. . .	193 331 57	. . .	. . .
16	Maynard, Mass.	8 110 33	4 560 42	1 807 33	6 367 75	626 55	6 994 30
18	Middleboro, Mass.	2 930 09	3 662 19	7 174 03	10 836 22	572 63	11 408 85
20	New Bedford, Mass.	5 795 02	73 192 32	34 391 32	107 583 64	580 26	108 163 90

21	New London, Conn.	. . .	. . .	. . .	$ 51 415 38	. . .	. . .
22	Newton, Mass.	. . .	$ 3 808 04	$ 99 828 85	103 636 89	$ 10 369 43	$ 114 006 32
23	Norwich, Conn.	. . .	42 604 58	10 744 66	53 349 24	2 172 24	. . .
24	Oberlin, Ohio	. . .	886 85	5 120 00	6 006 85	111 35	6 118 20
25	Plymouth, Mass.	. . .	. . .	. . .	23 025 02	1 115 99	24 141 01
27	Quincy, Mass.	. . .	. . .	. . .	69 300 00	. . .	69 300 00
28	Reading, Mass.	. . .	. . .	9 078 86	9 078 86	273 27	9 352 13
29	Reading, Pa.	. . .	127 265 57	39 057 99	166 323 56	920 66	167 244 22
31	Somerville, Mass.	. . .	161 201 05	51 116 54	212 317 59	1 815 77	214 133 36
32	Springfield, Mass.	$11 686 38	148 476 70	70 338 35	218 815 05	{ 736 00 19 008 46 }	238 559 51
33	Taunton, Mass.	. . .	. . .	. . .	58 427 84	396 58	58 824 42
34	Waltham, Mass.	4 043 60	60 572 54	8 698 32	69 270 86	1 328 76	70 599 62
36	Wellesley, Mass.	. . .	. . .	13 075 17	13 075 17	526 34	13 601 51
38	Winchendon, Mass.	372 23	13 26	4 434 82	4 448 08	47 77	4 495 85
39	Woburn, Mass.	. . .	34 766 45	6 114 33	40 880 78	884 09	41 764 87
40	Yonkers, N. Y.	14 184 91	. . .	. . .	117 145 68	8 194 46	. . .

1901.—TABLE 2, *Continued*.—FINANCIAL STATISTICS.—MAINTENANCE.

Number.	Receipts from Public Funds. F Hydrants.	G Fountains.	H Street Watering.	I Public Buildings.	J General Appropriation or Miscellaneous.	Total from Public Funds.	K Gross Receipts from All Sources.	Expenditures. AA Management and Repairs.	BB Interest on Bonds.	CC Total Maintenance for the Year.	DD Balance.	K Total.
1	. . .	. . .	. . .	. . .	. . .	. . .	$142 824 07	. . .	$ 44 015 00	. . .	$ 9 696 93	. . .
2	. . .	. . .	. . .	. . .	$ 5 000 00	. . .	32 412 84	. . .	13 192 50	. . .	3 01	. . .
3	. . .	. . .	. . .	. . .	21 590 00	$21 590 00	46 465 65	$13 699 72	21 590 00	$ 35 289 72	11 175 93	$ 46 465 65
4	$2 300 00	. . .	. . .	$119 96	749 15	3 169 11	6 002 25	2 402 25	3 600 00	6 002 25	. . .	6 002 25
5	3 000 00	. . .	$1 000 00	. . .	. . .	4 000 00	81 070 55	16 200 50	31 697 50	47 898 00	33 172 55	81 070 55
6		Included	in Receip	ts—Meter	Rates.		45 185 74	26 440 53	9 920 00	36 360 53	6 421 50[1] 6 403 71[2]	49 185 74
7	. . .	. . .	. . .	. . .	. . .	. . .	329 224 47	79 762 67	119 708 75[2] 127 109 00	326 575 42	2 649 05	329 224 47
8	2 002 50	$7 50	1 703 82	710 00	. . .	4 423 82	88 992 21	29 570 40[6] 14 941 94	12 000 00	. . .	5 410 00[2] 4 868 17[1] 22 201 70[5]	88 992 21
9	. . .	. . .	. . .	. . .	. . .	. . .	62 327 98	. . .	25 700 00	. . .	. . .	. . .
10	. . .	. . .	. . .	. . .	. . .	. . .	198 547 14	46 142 36	93 340 00	139 482 36	59 064 78	198 547 14
12	1 000 00	. . .	. . .	. . .	. . .	1 000 00	3 000 00	1 100 00	1 250 00	2 350 00	650 00	3 000 00
13	. . .	. . .	. . .	. . .	. . .	. . .	121 838 84	21 530 28	12 000 00	33 530 28	?	121 838 84
15	. . .	. . .	. . .	. . .	. . .	. . .	201 555 29	76 862 00	72 596 24	149 458 24	52 097 05[2]	201 555 29
16	2 000 00	6 60	. . .	. . .	48 82	2 055 42	12 160 05	3 400 86	5 000 00	2 389 23	1 369 96	12 160 05
18	. . .	. . .	. . .	. . .	. . .	1 500 00	15 838 94	5 008 06	2 300 00	7 308 06	3 000 00[2] 1 538 67[1] 3 992 21	15 838 94
20		12 000 00			72 580 00	84 580 00	198 538 92	36 107 59	77 580 00	113 687 59	30 000 00[4] 28 000 00[2] 26 851 33	198 538 92

21	$11 000 00	$ 150 00	$4 000 00	$ 400 00	. . .	. . .	$ 67 045 38	$ 6 877 90	$14 915 00	$ 21 702 90	$ 45 252 48	$ 67 045 38
22	14 250 00	828 00	3 000 00	2 207 00	. . .	$20 285 00	184 291 32	16 861 09	97 500 00	114 361 09	19 930 23	184 291 32
23	0	108 00	200 00	306 00	0	609 00	56 130 48	10 171 72	12 750 00	22 921 72	33 208 76	56 130 48
24	. . .	. . .	. . .	. . .	$4 010 01	4 010 01	10 128 21	2 846 00	1 647 54	4 493 54	5 634 67	10 128 21
25	. . .	. . .	. . .	. . .	. . .	0	24 141 01	11 374 17	4 527 60	15 901 77	8 239 24	24 141 01
27	. . .	. . .	. . .	. . .	. . .	. . .	69 300 00	10 000 00 24 000 00[3]	29 000 00	63 000 00	6 300 00	69 300 00
28	4 200 00	300 00	300 00	. . .	1 000 00	155 07[6] 5 800 00	15 307 20	6 567 20	8 740 00	15 307 20	. . .	15 307 20
29	. . .	. . .	. . .	. . .	. . .	0	167 244 22	38 753 99	19 104 00 7 500 00[2]	65 357 99	101 886 23	167 244 22
31	. . .	. . .	. . .	. . .	. . .	. . .	214 133 36	38 114 56 56 816 76[3]	8 270 00 82 000 00[4]	180 201 32	18 892 07[1] 65 039 97[5]	214 133 36
32	19 280 00	2 032 26	0	11 484 87	0	82 797 13	271 356 64	4 532 69[7] 22 613 29	87 250 00	114 395 98	?	?
33	0	2 276 32	0	505 75	2 054 91	. . .	63 661 40	23 640 70	32 868 00	56 508 70	7 152 00[2]	63 661 40
34	. . .	. . .	. . .	. . .	. . .	. . .	74 643 22	24 665 42	17 045 00	41 710 42	25 500 00[2] 7 432 80	. . .
36	———	5 000 00	———	133 72	. . .	5 133 72	18 735 23	5 932 22	11 080 00	17 012 22	1 723 01	18 735 23
38	3 800 00	255 00	153 60	. . .	. . .	4 208 60	9 076 68	2 428 73	3 800 00	6 228 73	2 847 95	9 076 68
39	. . .	250 00	250 00	550 00	. . .	1 050 00	42 814 87	11 627 99	4 774 00	16 401 99	26 412 88[2]	42 814 87
40	23 880 00	. . .	. . .	. . .	. . .	. . .	163 405 05	54 600 85	77 825 00	. . .	30 979 20[2]	163 405 05

[1] To Construction. [2] Sinking Fund. [3] Metropolitan Water Works Assessment. [4] Bonds Paid. [5] To City Treasury.
[6] From Construction Account. [7] Special.

1901.—TABLE 2, *Continued.*—FINANCIAL STATISTICS.—CONSTRUCTION.

Number.	Name of City or Town.	Construction Receipts.					
		Q	R	S	T	U	V
		Balance from Previous Year.	Bonds Issued.	Appropriations from Tax Levy.	Transferred from Maintenance Account.	Other Sources.	Total.
1	Atlantic City, N. J.	. . .	. . .	. . .	$19 529 39	$ 1 299 52	$20 828 91
2	Attleboro, Mass.	. . .	$20 000 00	. . .	. . .	1 086 00	21 086 00
3	Bay City, Mich.	$11 235 21	. . .	. . .	11 175 93	774 60	23 185 74
4	Billerica, Mass.	45 41	. . .	$396 70	. . .	. . .	442 11
5	Brockton, Mass.	4 111 46	28 000 00	. . .	. . .	3 588 11	35 699 57
6	Burlington, Vt.	. . .	. . .	. . .	6 421 50	. . .	6 421 50
7	Cambridge, Mass.	14 575 52	30 000 00	. . .	. . .	{ 1 530 00 91 39 }	46 196 91
8	Chelsea, Mass.	. . .	. . .	. . .	4 868 17	. . .	4 868 17
9	Concord, N. H.	. . .	. . .	. . .	. . .	. . .	. . .
10	Fall River, Mass.	. . .	20 000 00	. . .	. . .	. . .	20 000 00
13	Holyoke, Mass.	. . .	. . .	. . .	50 566 03	. . .	. . .
15	Lynn, Mass.	16 053 89	25 000 00	. . .	. . .	1 842 41	42 896 30
18	Middleboro, Mass.	. . .	. . .	. . .	1 588 67	1 001 07	2 589 74
20	New Bedford, Mass.	. . .	. . .	. . .	26 851 33	6 966 64	33 817 97
21	New London, Conn.	37 485 56	. . .	. . .	45 252 48	. . .	82 738 04
22	Newton, Mass.	. . .	14 285 23	. . .	. . .	45 013 08	59 298 31
24	Oberlin, Ohio	391 80	. . .	. . .	2 634 67	335 72	3 362 19

25	Plymouth, Mass.	. . .	$20 554 00	. . .	$ 1 599 24	$ 883 92	$ 23 037 06
27	Quincy, Mass.	. . .	30 000 00	. . .	. . .	3 000 00	33 000 00
28	Reading, Mass.	$ 48 93	6 835 83	$ 1 000 00	. . .	1 162 15	9 046 91
29	Reading, Pa.	54 815 97	. . .	. . .	101 886 23	6 253 81	162 455 51
31	Somerville, Mass.	. . .	. . .	. . .	18 892 07	313 52	19 205 59
32	Springfield, Mass.	0	. . .	. . .	12 703 70	1 165 10	13 868 80
33	Taunton, Mass.	38 343 51	. . .	15 000 00	. . .	8 250 27	61 593 78
34	Waltham, Mass.	5 590 49	6 000 00	. . .	. . .	4 101 84	15 692 33
36	Wellesley, Mass.	1 283 13	6 000 00	. . .	. . .	1 210 83	8 493 96
38	Winchendon, Mass.	. . .	. . .	5 500 00	642 38	. . .	6 142 38
39	Woburn, Mass.	10 98	. . .	650 00	. . .	397 81	1 058 79

1901.—TABLE 2, *Concluded.*—FINANCIAL STATISTICS.—CONSTRUCTION AND MISCELLANEOUS.

Number.	FF	GG	HH	II		KK	V	W	X	Y	Z
	Construction Expenditures.							Miscellaneous.			
	Extensions.			Speci		alance.	Total.	Net Cost of Works to Date.	Bonded Debt at Date.	Value of Sinking Fund at Date.	Average Rate of Interest, Per Cent.
	Mains	Services.	Meters.								
1	$10 868 64	. . .	$ 9 975 07	. .		. . .	$20 828 91	$1 110 742 01	$1 085 500 00	$116 962 68	4.76
2	. . .	. . .	. . .	$ 4 062 07	15 429 12	$1 594 81	21 086 00	389 917 30	317 000 00	62 493 40	. . .
3	8 666 25	. . .	640 62	. . .	9 307 07	13 878 67	23 185 74	607 461 62	382 000 00	. . .	6
4	. . .	$ 390 90	. . .	51 21	442 11	. . .	442 11	92 147 98	90 000 00	5 063 75	5
5	24 716 64	2 267 65	3 320 21	. . .	30 304 50	5 395 07	35 699 57	943 515 56	805 000 00	360 695 76	4
6	5 292 74	1 128 76	. . .	. . .	6 421 50	. . .	6 421 50	474 461 23	248 000 00	abt. 34 000 00	4
7	12 879 90	. . .	13 971 98	5 846 83	32 198 71	13 998 20	46 196 91	5 703 428 28	3 332 100 00	757 781 54	3¾
8	4 115 17	624 00	129 00	. . .	4 868 17	. . .	4 868 17	488 208 69	300 000 00	66 377 60	4
9	21 298 68	1 568 28	1 972 08	. . .	. . .	. . .	. . .	873 196 76	650 000 00	. . .	. . .
10	. . .	. . .	. . .	. . .	20 000 00	. . .	20 000 00	1 964 456 00	1 940 000 00	685 648 14	4.3
11	. . .	. . .	. . .	. . .	. . .	. . .	. . .	429 775 26	548 000 00	118 224 74	. . .
12	. . .	. . .	. . .	. . .	. . .	. . .	. . .	35 000 00	25 000 00	. . .	5
13	{ 450 00 / 30 006 68 }	. . .	759 85	22 850 00	. . .	. . .	. . .	1 295 808 26	300 000 00	42 657 14	. . .
15	1 641 19	4 906 74	. . .	9 879 70	16 427 63	26 468 67	42 896 30	2 487 871 15	1 775 300 00	641 484 09	abt. 4
16	. . .	. . .	. . .	. . .	. . .	. . .	. . .	154 000 00	125 000 00	17 690 69	4
18	1 949 43	414 27	176 04	. . .	2 539 74	. . .	2 539 74	117 966 89	54 500 00	6 630 42	4

20	$16 677 95	$ 3 736 06	$1 255 35	$ 779 87	$22 449 23	$11 368 74	$ 33 817 97	$3 150 052 82	$1 728 000 00	$181 727 69	4.41
21	20 814 29	1 712 83	. . .	58 984 00	81 461 02	1 277 02	82 738 04	788 440 46	501 000 00	. . .	abt. 3¾
22	9 176 57	8 518 48	6 997 85	34 610 96	59 298 31	. . .	. . .	2 089 285 23	2 100 000 00	915 070 19	4.7
23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	892 336 68	800 000 00	. . .	4¼
24	1 066 81	300 00	700 00	133 62	2 199 93	1 162 26	3 362 19	88 245 63	45 000 00	1 863 81	3½
25	14 749 96	439 16	. . .	7 847 94	23 037 06	. . .	23 037 06	328 378 21	119 320 00	. . .	abt. 3.9
26	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6 470 093 35	6 009 000 00	984 261 28	3.76
27	23 000 00	10 000 00	. . .	. . .	33 000 00	. . .	33 000 00	973 000 00	752 000 00	. . .	4
28	7 169 61	1 159 36	323 02	215 87	8 867 86	{ 155 07[1] 23 98 }	9 046 91	273 167 89	218 000 00	. . .	4
29	14 219 18	1 589 45	2 524 87	45 849 12	64 182 62	98 272 89	162 455 51	1 987 762 21	400 000 00	6 190 00	4
30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	527 000 00	131 754 66	abt. 3¾
31	. . .	. . .	. . .	. . .	19 205 59	. . .	19 205 59	785 690 22	175 000 00	. . .	4
32	5 174 62	. . .	. . .	8 694 18	13 868 80	. . .	13 868 80	2 141 263 26	1 475 000 00	541 046 80	5.85
33	7 953 90	3 567 21	2 106 09	39 566 12	53 193 32	8 400 46	61 593 78	1 288 128 54	829 200 00	206 026 54	4
34	. . .	. . .	. . .	. . .	11 678 80	4 018 53	15 692 33	615 986 47	432 000 00	124 718 96	3.88
36	6 921 11	——— 1 141 02 ———		. . .	8 062 13	431 83	8 493 96	329 569 59	281 000 00	98 591 96	4
37	. . .	. . .	. . .	. . .	. . .	. . .	. . .	131 614 87	100 000 00	. . .	4
38	4 541 08	985 16	616 14	. . .	6 142 38	. . .	6 142 38	117 675 41	93 000 00	. . .	4
39	. . .	1 046 23	. . .	. . .	1 046 23	12 56	1 058 79	597 697 56	97 650 00	989 55	4
40	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1 640 561 28	1 475 000 00	361 479 68	5.33

[1] To Maintenance Account.

1901. — TABLE 3. — STATISTICS OF CONSUMPTION OF WATER.

Number.	Name of City or Town.	1 Estimated Population. Total at Date.	On Line of Pipe.	3 Supplied at Date.	4 Total Co… tion fo… Yea… (Gallo…	.	8 Average Consumption. (Gallons per Day.) To Each Inhabitant.	9 To Each Consumer.	10 To Each Tap.
1	Atlantic City, N. J.	32 000 to 250 000	. .	. .	1 245 6	.	35 to 75	. .	709
2	Attleboro, Mass.	12 009	11 000	. .	147 9	338	34	37	. .
3	Bay City, Mich.	28 000	20 000	[illegible]	1 062 6	278	106	185	1 815
4	Billerica, Mass.	2 800	1 800	[illegible]	21 9	316	. .	45	. .
5	Brockton, Mass.	42 000	[illegible]	[illegible]	446 9	268	29	38	223
6	Burlington, Vt.	19 000	[illegible]	18 400	304 6	249	40	44	244
7	Cambridge, Mass.	92 716	92 716	92 716	2 785 1	566	81	81	529
8	Chelsea, Mass.	34 000	34 000	[illegible]	1 085 0	000	87	87	486
9	Concord, N. H.	19 632	17 000	. .	.	.	. .	. .	. .
10	Fall River, Mass.	107 831	. .	[illegible]	1 830 8	739	34	34	. .
11	Fitchburg, Mass.	31 531	. .	[illegible]	1 022 0	000[1]	. .	103	. .
12	Freeport, Me.	2 500	[illegible]	800	18 6	440	62	200	. .
13	Holyoke, Mass.	47 612	47 112	[illegible]	1 787 7	000[1]	103	105	1 831
15	Lynn, Mass.	74 000[3]	. .	72 500[2]	1 644 6	953	. .	63	. .
16	Maynard, Mass.	8 500	8 000	2 800	54 8	398	45	. .	. .

17	Metropolitan W. W.	844 800	. .	. .	87 044 840 000[3]	. . .	. .	101 492 000	120	. .	. .
18	Middleboro, Mass.	{ Town, 7 000 / F. Dist., 4 300 }	4 100	3 800	81 884 000	41 730 000	51	224 840	52	59	266
19	Minneapolis, Minn.	215 000	125 000	115 000	6 591 618 020	1 570 265 250	24	18 059 218	89	. .	. .
20	New Bedford, Mass.	65 000	58 000	57 000	2 150 199 262	561 404 250	26	5 890 957	91	108	624
21	New London, Conn.	18 300	17 000	16 000	508 429 000[1]	. . .	. .	1 379 300[1]	75	86	427
22	Newton, Mass.	34 200	33 700	33 400	673 200 749	411 000 000	61	1 848 276	54	55	256
23	Norwich, Conn.	24 637	21 500	20 000	730 000 000[1]	. . .	. .	2 000 000[1]	. .	. .	600[1]
24	Oberlin, Ohio	4 800	3 600	2 800	40 374 000	17 070 000	42	110 600	23	40	168
26	Providence, R. I.	198 700	198 700	198 700	3 918 165 542	. . .	60[1]	10 784 700	55	55	484
28	Reading, Mass.	5 000	4 840	4 265	57 479 577	24 260 843	42	157 478	31	37	143
29	Reading, Pa.	81 770	81 500	81 670	2 850 644 804	1 007 909 555	35	7 810 000	96	97	461
30	Schenectady, N. Y.	32 000	. .	. .	. . .	. . .	. .	. . .	. .	. .	. .
31	Somerville, Mass.	63 500	63 500	63 500	. . .	359 385 032	. .	. . .	. .	. .	. .
32	Springfield, Mass.	62 059	54 000	50 000	2 920 000 000[1]	433 077 915	15	8 000 000[1]	129[1]	160[1]	797[1]
33	Taunton, Mass.	31 036	28 000	26 604	631 214 244	227 749 181	36	1 729 354	56	65	374
34	Waltham, Mass.	24 175	23 750	23 700	886 407 890	47 902 226	6	2 291 528	95	97	685
35	Ware, Mass.	8 263	7 783	7 690	116 793 885	65 778 287	56	314 504	38	41	416
36	Wellesley, Mass.	5 240	5 135	5 097	88 975 417	45 467 748	51	245 220	46	47	271
38	Winchendon, Mass.	5 001	3 000	2 326	31 368 800	11 922 975	39	85 942	17	37	192
39	Woburn, Mass.	14 250	14 200	14 200	426 638 100	46 217 451	9	1 119 556	78	78	383
40	Yonkers, N. Y.	50 000	49 000	48 000	1 495 955 717	. . .	41	4 098 509	82	84	782

[1] Estimated. [2] Lynn and Saugus. [3] Of this, 214 600 000 was furnished from local sources.

1901.—TABLE 4.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—MAIN PIPES.

Number.	Name of City or Town.	1 Kind of Pipe.	2 Sizes of Pipes. (Inches.)	3 Length Extended During the Year. (Feet.)	4 Length Discontinued During the Year. (Feet.)	5 Total Length in Use. (Miles.)	6 Cost of Repairs per Mile.	7 Number of Leaks per Mile.	8 Length of Pipe Less than 4 Inches Diam. (Miles.)	9 Hydrants. Number Added.	10 Hydrants. Total in Use.	11 Gates. Number Added.	12 Gates. Total in Use.	13 Gates. Number Smaller than 4 Inch.	14 Gates. Number of Blow-off Gates.	15 Range of Pressure on Mains at Center. (Pounds.)
1	Atlantic City, N. J.	C. I.	4 -20	20 093	1 265	51 3	. .	. .	2 2	29	548	. .	. .	. .	9	. . .
2	Attleboro, Mass.	W. I., C. I., C. L.	1 -16	8 229	. .	33 2	. .	0 57	. .	15	278	. .	. .	. .	. .	54- 62
3	Bay City, Mich.	C. I., Wyckoff.	3 -20	8 736	8 003	45 5	$17 18	1 3	0 1	4	417	3	709	1	13	35- 38
4	Billerica, Mass.	C. I.	6 -12	. .	. .	9 7	2 12	1	. .	. .	101	. .	84	. .	4	54-120
5	Brockton, Mass.	W. I., C. L., C. I.	6 -30	17 373	0	68 8	2 29	0 35	. .	42	650	52	848	. .	23	47- 56
6	Burlington, Vt.	C. L., C. I., W. I.,	4 -30	7 399	3 479	39 0	6 86	0 3	2 8	1	214	15	633	59	12	70- 85
7	Cambridge, Mass.	C. I.	1¼-40	4 216	. .	124 3	. .	0 22	3 5	10	978	36	. .	. .	. .	40- 50
8	Chelsea, Mass.	C. I.	6 -16	3 256	. .	38 5	. .	. .	3 6	5	285	10	409	19	31	48- 50
9	Concord, N. H.	. . .	. .	15 345	10 047	61 2	. .	. .	. .	5	272	26	783	. .	. .	. . .
10	Fall River, Mass.	C. I.	6 -24	. .	. .	90 0	. .	. .	. .	37	991	46	986	. .	. .	80
11	Fitchburg, Mass.	C. I.	2 -30	4 789	. .	67 6	. .	. .	. .	13	512	10	564	. .	. .	{ 75 L. S. 155 H.S.
12	Freeport, Me.	C. I., Galv. I.	2 -10	. .	. .	3 8	0	0	1 3	0	19	0	18	4	0	50-100
13	Holyoke, Mass.	W. I., C. I., Ld. L.	½-30	7 625	0	82 9	10 00	0 10	5 7	12	750	36	770	3	31	80-100
15	Lynn, Mass.	W. I., C. L., C. I.	2 -20	2 471	. .	131 8	. .	0 66	. .	7	959	11	977	. .	. .	45- 60
16	Maynard, Mass.	C. I.	4 -12	2 595	0	9 5	0 99	0 5	0	2	90	5	85	. .	2	90- 95
17	{ Met. Water Works	C. I., C. L.	6 -60	11 500[1]	. .	72 0	. .	. .	. .	. .	. .	12	280	. .	. .	. . .
	Met. Water Dist. total in cities and towns }	C. I., C. L., Kal.	4 -60	191 000[1]	. .	1396 5	. .	. .	. .	366	12 279	. .	. .	. .	. .	. . .

18	Middleboro, Mass. .	C. I.	4 -12	392	. .	17 7	. .	0	0	1	121	1	175	0	6	45– 60
19	Minneapolis, Minn.,	C. I., W. I., Steel.	6 -50	38 776	0	276 6	$41 30	0 21	. .	85	3 312	84	2 348	. .	45	. . .
20	New Bedford, Mass.	C. I.	4 -36	13 722	2 302	94 9	20 54	0 3	1 20	12	750	27	1 092	80	97	37– 64
21	New London, Conn.	W. I., C. L., C. I.	4 -24	14 216	0	53 3	9 85	25	8 1	19	277	23	341	. .	30	40– 48
22	Newton, Mass. . .	C. I.	4 -20	7 051	450	187 9	2 00	0 05	2 9	6	961	8	809	47	388	80– 86
23	Norwich, Conn. . .	C. I., W. I.	½-16	436	0	42 8	5 09	0 23	2	3	369	0	418	28	15	81– 94
24	Oberlin, Ohio . . .	C. I.	4 -12	1 820	0	9 7	1 00	0 1	0 3	2	89	3	60	2	2	27– 32
25	Plymouth, Mass. .	C. L., W. I.	2 -20	15 661	2 868	44 4	16 50	2 29	8 6	48	180	106	451	185	32	. . .
26	Providence, R. I. .	C. I.	6 -36	35 823	1 114	381 0	0 38	0 06	0	34	1 920	80	3 478	0	82	64– 73
	H. P. Fire Service	C. I.	12 -24	. .	. .	5 6	. .	. .	. .	0	92	. .	81	. .	4	114
27	Quincy, Mass. . .	C. I.	4 -20	21 860	5 035	87 0	. .	1	6	42	576	53	1 044	118	8	80– 85
28	Reading, Mass. . .	C. I.	4 -12	8 134	. .	28 4	0 74	0 035	. .	21	161	9	243	. .	14	68– 78
29	Reading, Pa. . . .	C. I.	1½-36	9 938	4 533	101 7	45 29	0 67	0 9	21	760	82	2 295	15	56	43– 48
30	Schenectady, N. Y. .	. . .	. .	27 274	. .	45 0	. .	. .	. .	75	544	146	865	. .	. .	. . .
31	Somerville, Mass. .	C. I.	4 -20	11 652	. .	86 6	8 15	0 16	. .	29	968	45	1 248	. .	119	60–100
32	Springfield, Mass. .	C. I., W. I., C. L.	1 -36	10 830	2 722	146 2	5 89	0 29	7 7	9	964	35	1 924	371	89	30– 35 L. S. 100–120 H. S.
33	Taunton, Mass. . .	C. I.	4 -20	. .	. .	79 2	26 75	0 23	1 9	11	794	16	563	12	55	45
34	Waltham, Mass. . .	C. I., C. L.	2 -24	8 454	4 224	51 6	8 28	0 2	2 2	13	844	18	695	87	60	50– 70
35	Ware, Mass. . . .	C. I.	4 -12	3 119	0	12 1	. .	. .	0 5	2	116	2	121	10	3	90– 95
36	Wellesley, Mass. .	C. L., C. I.	4 -12	4 362	0	31 1	0 75	0 8	. .	12	282	21	226	3	4	70– 75
37	Whitman, Mass. .	C. I., C. L.	. .	. .	. .	17 5	. .	. .	. .	. .	157	. .	. .	. .	. .	65
38	Winchendon, Mass.	W. I., C. I.	2 -14	7 140	0	16 6	. .	0 42	1	10	131	9	173	28	11	103
39	Woburn, Mass. . .	C. I., C. L.	4 -14	. .	. .	54 0	13 74	1	5	. .	344	. .	423	50	12	70– 75
40	Yonkers, N. Y. . .	C. I.	3 -30	24 165	. .	84 7	21 69	1 7	0 8	62	858	39	550	3	24	. . .

[1] Less length abandoned.

1901.—TABLE 5.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—SERVICE PIPES.

Number.	Name of City or Town.	16	17	18	19	20	21	22		24	25	26	27		29	30
		Service Pipe.					Service Taps.				Meters.				Motors & Elevat'rs	
		Kind.	Sizes. (Inches.)	Extended. (Feet.)	Discontin'd. (Feet.)	Total in Use. (Miles.)	Number Added.	Total in Use.		Average Cost of Services for the Year.	Number Added.	Now in Use.	Percentage of Services Metered.		Added.	Total in Use.
1	Atlantic City, N. J.	C. I., Ld., Gal. I., Tin L.	⅝– 6	383	. .	0 88	. .	. .	. .	. .	341	5 089	79	. .	.	.
2	Attleboro, Mass. .	. . .	. .	. .	. .	. .	. .	. .	. .	. .	325	1 282	. .	. .	.	2
3	Bay City, Mich. . .	Lead, W. I., C. I.	⅝– 8	. .	. .	. .	55	2 256	. .	. .	55	881	39	60	.	.
4	Billerica, Mass. . .	Cem. Lined, W. I.	1 – 1½	1 707	. .	3 92	18	225	66 6	. .	20	88	86	51	.	.
5	Brockton, Mass. . .	{ W. I., Lead Lined, Cem. Lined, C. I. }	¾– 8	13 348	830	34	192	5 467	22 5	$10 85	223	4 528	83	88	2	8
6	Burlington, Vt. . .	Galv. I., C. I., Lead.	⅝– 6	2 042	79	18 5	70	3 420	28	8 00	90	2 401	70	81	2	25
7	Cambridge, Mass. .	Galv. Iron.	¾– 6	8 246	. .	100	201	14 408	39 8	19 71	1 070	1 898	13	33	7	30
8	Chelsea, Mass. . .	Lead.	⅝– 2	1 341	. .	31 5	52	6 198	28	12 00	8	118	2	23	.	6
9	Concord, N. H. . .	. . .	. .	. .	. .	14 67	57	3 278	. .	. .	132	1 142	35	61	.	.
10	Fall River, Mass. .	Lead.	½– 2	. .	. .	. .	182	7 075	. .	. .	211	6 755	96	. .	.	.
11	Fitchburg, Mass. .	W. I., Cem. L., C. I.	¾– 8	. .	. .	. .	104	4 586	. .	. .	98	2 592	56	. .	3	97
12	Freeport, Me. . .	Galv. Iron.	½– 2	200	0	1 25	3	170	40	. .	0	0	0	0	0	3
13	Holyoke, Mass. . .	{ Cem., Rub. Lined, Enam., C. I., Ld. Lined, Galv. I. }	⅝– 4	1 312	. .	13 9	73	3 675	20	15 18	28	233	6	18	1	97
15	Lynn, Mass. . . .	Cem. Lined, Ld. Lined.	¾– 4	. .	. .	97 6	175	12 732	. .	. .	322	2 808	23	. .	.	.
16	Maynard, Mass. . .	Cem. Lined.	¾	1 212	0	. .	38	588	49	5 56	6	85	20	. .	0	2
17	{ Met. Water Dist. total in cities and towns }	. . .	. .	. .	. .	. .	4 044	188 540	. .	. .	645	11 080	8	. .	.	.
18	Middleboro, Mass. .	W. I., Cem. Lined, Ld.	¾– 3	1 068	112	9 35	25	844	58	. .	20	860	43	66	0	7

19	Minneapolis, Minn.	Lead, Galv. Iron.	¾- 1	. .	. .	. .	. .	20 577	. .	. .	1 117	6 333	81	. .	0	20
20	New Bedford, Mass.	Lead, C. I.	½-10	4 139	2 457	61 41	167	9 447	84 8	. .	137	1 566	17	32	9	125
21	New London, Conn.	{ W. I., Cem. Lined, Galv. I., C. I., Lead. }	½- 4	2 392	139	11 7	141	3 229	19 2	$10 78	22	251	8	. .	0	17
22	Newton, Mass. . .	Galv. I., Tarred I., Ld.	¾- 6	10 075	3 021	80 3	100	7 181	59	27 73	209	6 109	85	96	0	17
23	Norwich, Conn. . .	W. I., Lead.	½- 6	997	75	15 5	42	3 500[1]	23	. .	0	112	8	20	2	42
24	Oberlin, Ohio . . .	Galv. Iron, Lead.	¾- 2	. .	. .	. .	35	660	25	8 00	41	432	75	85	0	0
25	Plymouth, Mass. .	Lead, Cem. Lined.	½- 4	825	. .	6 1	82	1 975	16 8	5 61	. .	. .	. .	. .	0	1
26	Providence, R. I. .	Lead, C. I.	¼-10	. .	. .	. .	701	22 186	. .	. .	731	18 544	84	. .	4	165
27	Quincy, Mass. . .	Lead Lined.	¾	26 000	. .	. .	300	4 630	40	15 00	22	147	3	. .	.	.
28	Reading, Mass. . .	{ C. I., Galv. I., Cem. Lined, Ld. Lined. }	¾- 6	2 774	150	14 6	48	1 104	69 9	24 15	25	987	89	. .	.	3
29	Reading, Pa. . . .	Ld., W. I., C. I., Ld. L'd.	½- 8	. .	. .	. .	577	16 942[1]	. .	. .	95	814	5	24	1	8
30	Schenectady, N. Y.	. . .	. .	. .	. .	. .	646	7 716	. .	. .	600	. .	. .	. .	.	.
31	Somerville, Mass. .	{ Ld., Ld. Lined, Cem. Lined. }	½- 6	8 733	. .	66 8	229	10 520	. .	18 26	22	224	2	24	0	8
32	Springfield, Mass. .	{ Ld., Cem. Lined, Tarred, Galv. I., C. I. }	½- 6	. .	. .	. .	270	10 034	. .	. .	215	3 337	33	32	24	245
33	Taunton, Mass. . .	Cem. Lined, Tin Lined.	¾- 3	. .	. .	44 5	131	4 613	. .	. .	102	1 934	42	. .	1	17
34	Waltham, Mass. . .	C. I., W. I.	¾-12	7 330	952	39 8	70	3 345	76	43 35	12	93	3	12	0	6
35	Ware, Mass. . . .	Cem. Lined.	1 - 2	4 840	845	9 5	21	755	62 2	. .	21	754	100	. .	0	10
36	Wellesley, Mass. .	{ C. I., Cem. Lined. Ld. Lined. }	½- 6	3 132	326	66 1	32	898	98	15 77	24	854	100	. .	0	0
37	Whitman, Mass. .	. . .	. .	. .	. .	. .	. .	1 008	. .	. .	. .	477	44	. .	.	.
38	Winchendon, Mass.	W. I.	1 - 2	2 840	0	4 1	62	447	47	15 89	58	434	97	99 7	0	0
39	Woburn, Mass. . .	Ld. Lined, Cem. Lined.	1	. .	. .	. .	31	2 925	. .	21 56	7	74	2	14	.	9
40	Yonkers, N. Y. . .	Lead, C. I.	⅜- 8	. .	. .	. .	270	5 238	. .	. .	304	5 156	99	. .	1	10

[1] Estimated.

PROCEEDINGS.

June Meeting.

Boston, June 25, 1902.

The June meeting of the Association was devoted to a boat excursion down Boston Harbor, a shore dinner at Nantasket Point, Hull, and a visit to the works of the Fore River Ship and Engine Company, at Quincy.

The attendance was as follows: —

Members.

C. F. Allen, E. W. Bailey, Charles H. Baldwin, L. M. Bancroft, C. H. Bartlett, J. E. Beals, J. W. Blackmer, George Bowers, G. A. P. Bucknam, Edward W. Bush, L. Z. Carpenter, E. J. Chadbourne, J. C. Chase, F. W. Clark, M. F. Collins, B. I. Cook, H. A. Cook, J. W. Crawford, A. O. Doane, L. S. Doten, E. R. Dyer, August Fels, R. J. Flinn, Fred B. Forbes, F. F. Forbes, E. V. French, A. D. Fuller, H. F. Gibbs, J. C. Gilbert, T. C. Gleason, Albert S. Glover, F. W. Gow, E. H. Gowing, J. O. Hall, V. C. Hastings, H. G. Holden, J. A. Huntington, Willard Kent, C. F. Knowlton, N. E. Mather, W. E. Maybury, N. A. McMillen, F. E. Merrill, H. A. Nash, Jr., Thomas Naylor, F. L. Northrop, C. E. Peirce, J. H. Perkins, C. E. Riley, W. W. Robertson, H. E. Royce, P. P. Sharples, E. M. Shedd, C. W. Sherman, Wm. B. Sherman, G. H. Snell, J. A. St. Louis, G. A. Stacy, J. T. Stevens, W. F. Sullivan, F. L. Taylor, L. A. Taylor, R. J. Thomas, H. L. Thomas, Wm. H. Thomas, D. N. Tower, W. W. Wade, C. K. Walker, J. C. Whitney, F. B. Wilkins, G. E. Winslow, E. T. Wiswall. — 72.

Associates.

Ashton Valve Co., by C. W. Houghton; Harold L. Bond & Co., by G. S. Hedge; Chapman Valve Mfg. Co., by Edward F. Hughes; Chas. A. Claflin & Co., by Charles A. Claflin; Garlock Packing Co., by Horace A. Hart; Hersey Mfg. Co., by Albert S. Glover; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; National Meter Co., by J. G. Lufkin and Charles H. Baldwin; Neptune Meter Co., by H. H. Kinsey; Norwood Engineering Co., by H. W. Hosford; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by F. S. Bates; A. P. Smith Mfg. Co., by W. H. Van Winkle; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by J. K. P. Otis, Edward P. King, F. L. Northrop, and C. L. Brown. — 21.

GUESTS.

H. F. Peck, H. L. Thayer, and Mrs. E. J. Chadbourne, Wakefield, Mass.; Elmer P. Vaughan, Oakland, Cal.; Mrs. Edward M. Shedd, Somerville, Mass.; Mrs. Wm. B. Sherman, Providence, R. I.; J. J. Moore, Hingham, Mass.; Capt. and Mrs. Albion Miller, New Orleans, La.; George Hardwick, E. J. Johnson (City Engineer), and Mrs. H. G. Holden, Nashua, N. H.; Mrs. C. S. Proctor, Mrs. A. Fels, Misses Fels, Ellen M. Weaver, F. L. Weaver, Mrs. Bucknam, Miss Hillman, Mr. and Mrs. Kelly, Mrs. J. W. Crawford, Mrs. George Bowers, Miss Bowers, and W. J. Dowd, Lowell, Mass.; Miss Emma L. Hastings, Concord, N. H.; J. F. Gleason, Quincy, Mass.; John W. Churchill (Water Commissioner), Plymouth, Mass.; Mrs. Charles W. Sherman, Belmont, Mass.; John H. Cook, Paterson, N. J.; Charles H. Choate (President Board of Aldermen), Joseph James (Master Mechanic Pacific Mills), A. H. Robinson, Daniel Gallagher, Charles H. Donovan, J. J. Desmond, and E. L. Arundel (Members Water Board), Lowell, Mass.; Walter L. Beals, Chester E. Weston, and Amos H. Eaton (Chairman), Middleboro, Mass.; J. G. Manuel (Assistant Superintendent) and L. P. Stone, Natick, Mass.; T. J. Flinn, H. M. Flinn, and T. T. Hubbard, West Roxbury, Mass.; Charles F. Merrill, Fred E. Warren, Miss Soule, and Charles E. Parks, Somerville, Mass.; Joel C. Gleason, S. W. Gleason, Mrs. J. A. St. Louis, Mrs. George A. Stacy, Mr. and Mrs. C. B. Russell, and A. F. Berry, Marlboro, Mass.; Mr. and Mrs. G. T. Staples, Dedham, Mass.; Mrs. Thomas Naylor and H. Naylor, Maynard, Mass.; Mr. Cannon (Water Registrar), Clinton, Mass.; Mrs. F. W. Clark, Newton Highlands, Mass.; Mrs. W. E. Maybury and Mrs. James T. Stevens, Braintree, Mass.; W. H. Hawkins and Miss Hawkins, Binghamton, N. Y.; Mrs. C. F. Knowlton and Mrs. J. F. Gleason, Quincy, Mass.; B. Sturgard, Lynn, Mass.; George H. Lamson and Mrs. Mary E. Lee, Woodward, Ia.; Mrs. C. E. Peirce, East Providence, R. I.; A. R. McCallun (Superintendent) and C. F. Allen, Whitman, Mass.; Mrs. C. W. Houghton, Mrs. C. C. Dalton, Mr. and Mrs. B. L. Arey, H. M. Crossland, J. A. Mitsch, Capt. E. W. Sears, and W. H. Greenwood, Boston, Mass. — 83.

SUMMARY OF ATTENDANCE.

Members	72
Associates	21
Guests	83
	176
Counted twice	2
Total attendance	174

A short business meeting was held on the boat, with President Merrill in the chair, and the following candidates for membership, who were recommended by the Executive Committee, were elected:—

Resident Members.

George K. Boutelle, Treasurer Kennebec Water District, Waterville, Me.

John H. Flynn, Assistant Superintendent Boston Water Works, Roxbury, Mass.

Edward J. Johnson, City Engineer, Nashua, N. H.

Clarence A. Perkins, Water Commissioner, Malden, Mass.

George T. Staples, Superintendent Water Works, Dedham, Mass.

Norman W. Stearns, Civil Engineer, Roxbury, Mass.

Thomas H. Wiggin, Civil Engineer, Boston, Mass.

Frederick W. Witherell, Assistant in Engineering Department, State Board of Health, Winchester, Mass.

Non-Resident Members.

Kenneth Allen, Engineer and Superintendent of Water Works, Atlantic City, N. J.

H. N. Blunt, Assistant Superintendent Palmer Water Company, Palmerton, Pa.

Theodore Horton, Civil Engineer, New York City.

Charles Gilman Hyde, Assistant Engineer in charge of filtration, Harrisburg, Pa.

Announcement was made that the headquarters of the Association during the Annual Convention, which will be held in Boston, September 10, 11, and 12, will be at the Hotel Brunswick, Boylston Street.

Adjourned.

Meeting of the Executive Committee.

Boston, June 25, 1902.

The Executive Committee met on board the boat, before the meeting of the Association, with President Merrill in the chair, and present also Messrs. C. K. Walker, H. G. Holden, G. A. Stacy, L. M. Bancroft, C. W. Sherman, W. B. Sherman, R. J. Thomas, and Willard Kent, Secretary.

Twelve applications for membership were received, and it was voted to recommend the applicants to the Association for election.

The sub-committee on Annual Convention reported that it had selected as headquarters, during the convention, the Hotel Brunswick, Boylston Street, Boston.

Adjourned.

OBITUARY.

William Downey, elected a member of this Association June 14, 1899, died October 1, 1901.

Mr. Downey entered the water department of Worcester, Mass., in 1883. He was employed in various capacities until about 1895, when he was made general foreman in charge of outside work, which position he held at the time of his death. He was forty-three years old, and left a wife and two children.

Joseph C. Hancock, superintendent of Water Works at Springfield, Mass., died on July 12, 1902, at the age of seventy.

Mr. Hancock was one of the original members of the Association, his membership dating from June 21, 1882. He had been superintendent of the Springfield Water Works for thirty-eight years.

Frank E. Fuller, who was elected a member of this Association on March 14, 1900, died on August 1, 1902.

Mr. Fuller was born April 28, 1871; he was graduated from the Newton High School in 1890, and entered the Chandler Scientific School of Dartmouth College, but was forced to leave before the completion of the first year by a serious illness, which permanently undermined his health. In 1892 he entered the office of the city engineer of Newton; in 1895 he was employed in the engineering department of the Boston & Albany R. R. In 1897 he entered the employ of the engineering department of the Metropolitan Water Works, where he remained until December of 1901, leaving to take a sea voyage for his health. He finally reached Santa Cruz on the island of Tenerife, where he died after a lingering illness. He left a wife, but no children.

BOOK NOTICES.

" Diagrams of Mean Velocity of Uniform Motion of Water in Open Channels; Based on the Formula of Ganguillet and Kutter." By Irving P. Church, C.E., Professor of Applied Mechanics and Hydraulics, College of Civil Engineering, Cornell University. John Wiley & Sons, New York. Price $1.50.

Professor Church says: " It is perhaps quite generally admitted among hydraulic engineers that on account of the uncertainty usually attending the choice of a proper 'coefficient of roughness' (n) in the use of Kutter's formula, it is well-nigh useless to observe great refinement in the employment of that well-known equation for the mean velocity of uniform motion of water in open channels. Suitable diagrams, therefore, can furnish solutions of this equation which answer every practical purpose. A collection of such diagrams is here presented, one for each of eleven values of 'n.' (from .009 to .035), and ranging from 0.1 feet to 25 feet in the value of R, the hydraulic radius, the slope varying from 0.01 feet per thousand to 100 feet per thousand (that is, from $S = 0.00001$ to $S = 0.100$)."

The diagrams are very clear, and should be of much value to hydraulic engineers.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVI. December, 1902. No. 4.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE WATER SUPPLY OF NASHUA, N. H.

BY HORACE G. HOLDEN, SUPERINTENDENT, NASHUA, N. H.

[*Read September 10, 1902.*]

Has it ever occurred to you what great changes have been made during the past twenty years in the water systems of this country? Formerly nearly all of the works derived their supplies from surface waters, either lakes, ponds, or running streams. These supplies were supposed to be unlimited in quantity and were apparently all right in quality; but the large increase of population, the building up of manufacturing industries, together with summer resorts on the shores of the lakes and streams, have caused many of the water supplies to be so contaminated with sewage, consisting of house drainage and mill refuse, as to not only render them unfit for domestic use, but also for steam boilers and other purposes where pure water is required.

To remedy this condition, filter systems were introduced on many of the works. Some of these have proved successful, while others have been failures; but it is doubtful if the average water taker can ever be convinced that liquid sewage can be so strained or clarified that it will not still remain liquid sewage.

For a period of forty-seven years, from 1853 to 1900, the city of Nashua, N. H., received its entire water supply from Pennichuck Brook, the outlet of a chain of ponds located in the town of Hollis. After leaving what is called the Big Pennichuck Pond the brook flows for six and one-half miles, as shown on the map, Fig. 1, forming the boundary line between the city of Nashua and the town of Merrimack, until it finally reaches the Merrimac River, about three miles above the Hudson Bridge.

In 1853 the water company built the first stone dam, about three-

fourths of a mile above the mouth of the brook. (Plate I, Figs. 1 and 2.) This dam is twenty-six feet in height, and the reservoir formed by it flows back eighteen hundred feet, to where another stone dam,

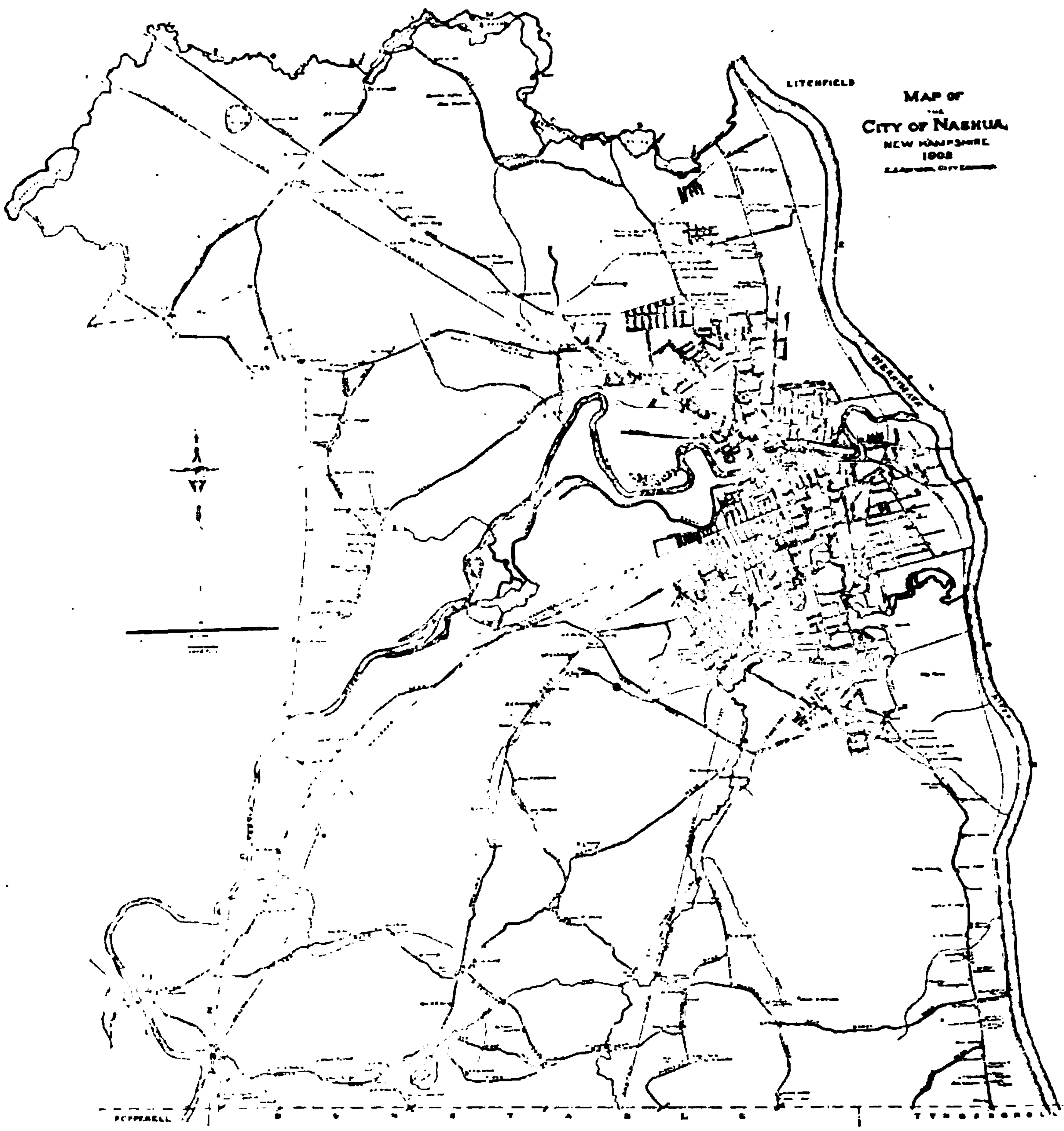


FIG. 1.*

thirty feet high, is located. Beyond this dam there are two more dams, each forming a reservoir of over a mile in length.

At the first or lower dam there are three pumping stations. The

* The upper part of the map shows the location of the Pennichuck Brook and reservoirs.

PLATE I.

FIG. 1. — FIRST OR LOWER DAM ON PENNICHUCK BROOK. PUMPING STATIONS NOS. 1 AND 3.

FIG. 2. — LOWER RESERVOIR AND PUMPING STATIONS.

No. 1 Station was built in 1853. It has a three-million-gallon steam pump and a two-million-gallon power pump. No. 2 Station was built in 1893, and has an eight-million-gallon triple expansion steam pump. No. 3 Station is located below the dam. It was built in 1900, and has a six-million-gallon power pump, the wheel driving it being run by water flowing through a seventy-two-inch steel penstock leading from the reservoir formed by the second dam, giving a head of sixty feet of water on the wheel. The second dam is shown in Plate II, Fig. 1.

The penstock is intended to be of sufficient size to carry all the water that ever runs in the brook, so that at present no brook water gets into the lower reservoir, from which is pumped the water now used by the city of Nashua.

The land on both sides of the brook from its mouth up to the fourth dam, a distance of three and eight-tenths miles, is now principally owned by the water company, which controls an area of nearly one thousand acres. This land was formerly used for grazing and tillage, but since coming into the possession of the water company it has been allowed to grow up into woodland, so that at present most of it is covered by quite a heavy growth of white pine, and this practically eliminates all danger of any outside contamination to the brook.

In 1892 Mr. Frederic P. Stearns, who at that time was the chief engineer of the Massachusetts State Board of Health, made a careful examination of the brook, and in his report to me mentions that the amount of albuminoid ammonia (organic matter) is unusually low. He also says: "I have compared it with a list of one hundred and four surface waters in Massachusetts and find there are but twenty-five lower, and seventy-nine higher. Of the twenty-five lower, all but two or three are mountain streams or small reservoirs fed by springs."

We have had here what might be considered an ideal water supply, with storage reservoirs of sufficient capacity to furnish a daily supply of at least ten million gallons of practically pure water, even in the dryest seasons, provided that the pumping was done by steam power. And even of late years the only question that has ever been brought up regarding the quality of the water was that, as is the case with most surface waters, there were times, especially in the spring of the year, when the water was discolored and also developed a decidedly swampy taste, undoubtedly caused by the meadows which line the upper end of the brook.

However, without much searching or any expectation of ever getting a better water supply, we accidentally came across one which is in every way superior to our brook supply.

About one eighth of a mile south of our lower reservoir there is a meadow containing about five acres, which has always been noted for having a number of springs of remarkably pure water. At times when our city water developed the swampy taste, many of the citizens of Nashua would occasionally drive up to these springs to fill their jugs and bottles with this spring water. The water company had owned this meadow for several years, and in order to accommodate those who preferred spring water, I laid a plank walk into the meadow to what was considered the best spring, and one day took up a twenty-four inch cement pipe, three feet long, such as is used in sewer work, intending to settle this pipe into the ground, so as to be nearly level with the surface of the water, then clean out the mud from the inside of the pipe, leaving a good well, from which the water could be dipped without affecting its clearness.

On ending the pipe up over the spring, I was surprised to find that by the time the pipe had settled a foot into the meadow, the water came up inside the pipe so as to flow over the top, which was about twenty-four inches above the level of the surrounding ground.

The level of the meadow is twenty-four inches above the high-water line of the lower reservoir, and there was what had once been a water-course leading from the meadow to the reservoir, but which had been filled up with decaying vegetation, — dead trees, etc. After clearing out this channel, there was quite a flow of water from the meadow into the reservoir.

Just before reaching the reservoir, the water-course runs through a narrow gorge about ten feet wide, with nearly vertical sides some twenty feet high. At this point a small dam twenty-four inches in height has been built, with a weir for measuring the flow of water from the meadow. The flow over this weir was very uniform, never at any time being less than one million gallons per day, while the maximum daily flow was rarely over 1 250 000 gallons.

The next season I drove several two and one-half inch pipes in different sections of the meadow, and succeeded in getting a good stream of water to flow from each of them. I then sunk a six-inch wrought-iron pipe in the north section of the meadow to the depth of 32.75 feet. There is a continuous flow from this pipe of 274 gallons per minute, or nearly 395 000 gallons per day.

PLATE II.

FIG. 1.—SECOND DAM ON PENNICHUCK BROOK.

FIG. 2.—THE PENNICHUCK SPRINGS. SHOWING THE 6-INCH AND TWO 2½-INCH FLOWING WELLS.

The surface of the meadow is covered with a layer of muck or loam, varying from one to six feet in depth. Below this, as was indicated by samples taken while driving the six-inch pipe, there appear to be alternate layers of marl, sand, fine gravel and coarse gravel, the water flowing mostly from the gravel layers. In driving the two and one-half inch pipes, a very good flow of water would occasionally be obtained from a depth of fifteen or sixteen feet, then, on driving farther, the flow would stop entirely, but on driving still deeper the flow would commence again.

Accurate measurements of the flow would be taken at every foot at which the pipe was driven, and after driving as far as could be easily done, the pipe would be drawn up to the place where the greatest flow was obtained. After driving the six-inch pipe previously mentioned, twelve 2½-inch pipes were driven, commencing at a point thirty-eight feet south of the six-inch pipe and running west in a straight line one hundred and sixty-eight feet, making the average distance between the pipes fourteen feet. Some of these wells are shown in Plate II, Fig 2. The depth at which the greatest supply of water was obtained from these pipes varied from sixteen feet seven inches to thirty-one feet eight inches. The flow from each pipe varied from 19.4 to 41.4 gallons per minute, the total flow from these twelve pipes being 352.9 gallons per minute, or 408 166 gallons per day.

Another line of six 2½-inch pipes was driven at the extreme southerly end of the meadow, the average distance between the pipes being seventeen and one-half feet. The greatest flow from these pipes was obtained at from thirty-six to fifty-two feet in depth, this flow being from 23.1 to 46.1 gallons per minute. The total flow from these six pipes is 273 744 gallons per day.

There is a daily flow from the six-inch pipe, and the eighteen 2½-inch pipes, amounting to 1 127 520 gallons. During the past three years I have frequently measured this flow and found but slight variation.

These wells increase the flow of water over the weir to about two and one-half million gallons per day, and whenever the pipes are plugged, the flow on the weir decreases proportionally, showing that the surface springs are not affected by the wells.

From these tests, I feel confident that a large number of pipes might be driven in this meadow and a very large amount of water obtained.

The following is a report of an analysis of water taken from one of the surface springs by Henry J. Williams, of Boston, chemical engineer and analytical chemist.

	Parts per 100 000.
Total Solids	3.7
Volatile and Organic Matter	0.5
Fixed Solids or Mineral Matter	3.2

The mineral matter contains: —

Silica	trace
Sesquioxide of Iron	faint trace
Alumina	none
Lime	1.42
Magnesia	0.14
Sulphuric Acid	0.498
Chlorine	0.20
Degree of Hardness	1.5
Free Ammonia	0.001
Albuminoid Ammonia	0.003

The above results show very plainly that this "spring" water is a very soft and unusually pure water, both in its freedom from organic matter and its freedom from mineral matter. Its purity in these two respects is unusual, and it is, therefore, admirably fitted for household use and for drinking. The amount of chlorine which the water contains is also very low, while the trifling amounts of mineral matter which are present are of entirely unobjectionable nature.

The constituents found in the analysis of the mineral matter occur in the water in the following probable states of combination: —

	Parts per 100 000.
Silica	trace
Sesquioxide of Iron	faint trace
Alumina	none
Sulphate of Lime	0.847
Carbonate of Lime	1.912
Chloride of Magnesia	0.210
Carbonate of Magnesia	0.126
Sodium Chloride	0.071
	3.166

The water also has a neutral reaction, that is, it is neither acid nor alkaline.

During the summer months the temperature of the water as it flows from the pipes is about forty-six degrees, but about the first of October the temperature gradually increases, and reaches sixty-three degrees by December, and by the last of April drops back to forty-six degrees. Professor Sedgwick informs me that this change of temperature is probably caused by the water flowing underground from a long distance, and if his theory is correct (as I have no reason to doubt) it may be possible that this water comes from a continuation of the underground river which Professor Denton, formerly of Harvard College, is said to have traced from Narragansett Bay to the New Hampshire state line, according to an item which was published in February, 1902, in several Massachusetts papers. This item related to the suit of Hollingsworth and Vose against the town of Foxboro, for taking water for water supply purposes from the Neponset River. The town claimed, however, that their supply, which is taken from wells, is derived from a subterranean river.

About one and one-half miles southwest of our springs there is another meadow similar to the one I have described, in which I drove a few pipes and was successful in getting flowing wells. This property is now owned by the United States Fish Commission, who get from flowing wells enough water to supply all the requirements of their fish hatcheries.

A NEW TURBIDIMETER.

BY CHARLES ANTHONY, JR., CIVIL ENGINEER, GLENVIEW, HEREFORD, ENGLAND.

[*Read September 11, 1902.*]

The determination of the turbidity of water is a factor which now occupies a more prominent position in deciding on the organoleptic qualities of a public water supply than formerly. Nevertheless, there are few points on which greater diversity of procedure exist; and among the many methods employed none can be considered altogether satisfactory.

These methods can all be resolved into one or other of the following three classes: —

1. The gravimetric.
2. The photometric.
3. The use of standards of comparison.

The first may be called the standard method, at all events from the water analyst's point of view. Indeed, formulæ have usually been applied to determinations by other methods, with the object of reducing them to equivalent weights of suspended matter in parts per million. But seeing that the finely suspended matter, consisting generally of clay and silica, is entirely harmless, and that it is only the appearance they impart to the water which is considered by the consumer, this proceeding appears unnecessary, not to say tautological.

The following are the principal methods hitherto employed in estimating turbidity: —

1. The gravimetric.
2. Lovibond's tintometer (colored glass standards, depth of tints varied).
3. Tidy's colorimeter (colored solution standards, thickness of solution varied).
4. Boston commissioners' colorimeter (colored glass standards, thickness of water varied).
5. Platinum and cobalt chloride standard (concentration of solution varied).

6. Silver chloride standard (concentration of solution varied).
7. Leed's Nessler standard (concentration of solution varied).
8. Stokes' Nessler standard (thickness of solution varied).
9. Kaolin standard (amount of kaolin varied).
10. Silica standard (amount of silica varied).
11. Horning's diaphanometer.
12. Hazen's platinum wire standard.
13. Salback's photometric method.

The first, or gravimetric, may be dismissed as being a difficult and tedious method, giving only approximate results, even in the hands of a capable water analyst, working in a well-equipped chemical laboratory.

The second, Lovibond's tintometer, is not well adapted to the examination of water, and is, as its name implies, not a measure of turbidity but rather of color. Its scale is, moreover, entirely arbitrary.

The third, Tidy's colorimeter, requires the preparation of standard solutions, has a restricted scale, and labors under the same disadvantages as the last.

The fourth, Boston commissioners' colorimeter, is open to the same objections as those above described.

The fifth, platinum and cobalt standard, though well recognized as a standard of color, is not a measure of turbidity, and is open to the same objection of arbitary scale as the above.

The sixth, seventh, and eighth are arbitrary standards which represent no rational scale, either as to the amount of suspended matter by weight, or amount of light absorbed.

The ninth and tenth are means of obtaining, by comparison with known standards, an approximate idea of the weight of matter in suspension, more easily than by the gravimetric method.

The eleventh, twelfth, and thirteenth are methods depending upon photometry. The eleventh, Horning's diaphanometer, depends upon the limiting depth at which an object remains visible through a tube of water; the twelfth, Hazen's platinum wire, upon the depth at which a platinum wire of one millimeter diameter becomes invisible in the water under examination; and the thirteenth, Salback's, is simply a photometer of cumbersome construction, necessitating the use of two artificial lights of equal intensity.

Of all these, as a turbidimeter in contradistinction to a colorimeter, the twelfth, Allen Hazen's platinum wire method, is the most practical. It is, indeed, the acme of simplicity, but labors under

two serious drawbacks: that its scale — the reciprocal of the depth in inches at which the wire becomes invisible — is entirely arbitrary, and that observations made under different conditions of illumination are not strictly comparable. It may be dismissed, therefore, as not a strictly accurate or scientific method, though useful in practice in certain cases on the score of simplicity.

From the above it may be seen that all hitherto employed methods are deficient, either on the score of difficulty and tediousness, or on account of irrational scale and deficient accuracy. In consequence some simple photometric method of measuring the absolute amount of light absorbed by a given thickness of water appears to the writer the most rational and convenient method of estimating the degree of turbidity of a water, and with this object he has designed the form of instrument illustrated in the following figure (Fig. 1).

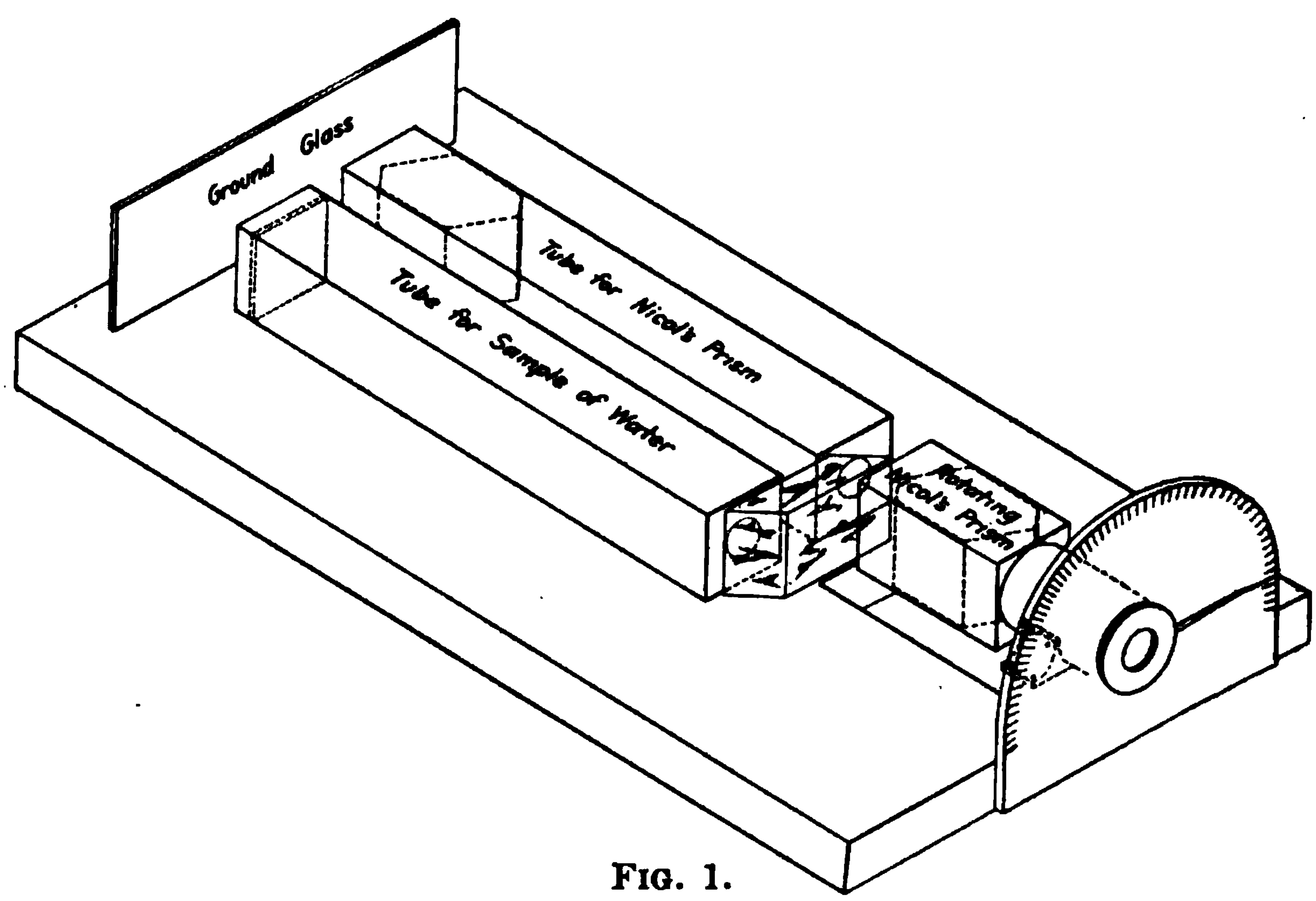


FIG. 1.

It consists, as will be seen, of a couple of parallel tubes of standard length, say fifty centimeters, one of which, closed at the ends by plates of glass, contains the water to be examined. Light transmitted preferably through ground glass reaches the eye, in part through this water and in part direct after passing through a Nicol's polarizing prism. These two sources of light are observed through an eyepiece containing another Nicol prism. The field of view is thus seen neatly dichotomized. By rotating the eyepiece, the illumi-

nation of that half of the field which received its light direct, seeing that it has already passed through a Nicol prism, can be varied until it matches the half receiving light through the standard thickness of water under examination. And though the inevitable difference in tint introduces some error due to personal equation in estimating equal obscuration, the extremely convenient manner in which the lights from the two sources are seen in absolute juxtaposition in the same field of view, allows of more accurate comparison than by any of the methods hitherto suggested. Further, seeing that the obscuration varies, according to a well-understood relation, with the angle through which the eyepiece is rotated, the instrument can be made to indicate, on a properly graduated disc, the degree of obscuration, that is, turbidity, to a rational scale, in which 1 represents perfect transparency and 0 total obscuration.

In conclusion it may be pointed out that the instrument is most easy to handle, gives accurate results to a rational scale, and is independent of the source of light. For these reasons the writer believes it well adapted to fill the long-felt want of a ready and standard means of making turbidity observations.

DISCUSSION.

The President. I will call upon Mr. Hazen to say something upon the subject of Mr. Anthony's paper.

Mr. Allen Hazen.* Mr. President, this method of determining turbidity is an absolutely new one to me. It looks like a very interesting method; and I should very much like to see an apparatus constructed according to this illustration, and compared experimentally with some of the methods of measuring turbidity with which we have had practical experience.

The author seems to be not quite clear in his distinction between color and turbidity. The two things are so different that no one who has had experience with them both would think of measuring them on the same scale, and the author is evidently not quite clear as to the distinction when he lists the methods of measuring color with the methods of measuring turbidity.

The objections to the wire method, which the author mentions in so complimentary a manner, have been fully recognized by us for a long time. The method was based on methods which have been used from a very early time, and was put in use at Lawrence thirteen

* Civil Engineer, New York, N. Y.

years ago. Some work was being done for which a definite scale for recording the turbidities of certain waters was absolutely necessary. The scale was arbitrary. It had to be arbitrary. There were no data available at the time to make a scale in any other way. Since that time a great many data have been collected bearing on what a rational scale should be, and, as I hope to tell you this afternoon,* a scale has been constructed based upon these data which approximately meets the actual conditions, so that the figures as read are directly proportional to the amount of turbidity-producing material in the water. And this is, I believe, the object to be sought in making a turbidity scale.

The other objection mentioned to the wire method, that the results vary according to the light, is less serious in practice than might be at first supposed. Certain regulations are made in regard to the amount of light, which are followed as far as possible, and within the limits specified the differences do not cause a considerable error in the results.

There is a third source of error which seems to have escaped the attention of the author, but which is quite as important as those mentioned, and that is the differences in the eyes of different observers. This also is a matter which has to be guarded against, and is best done by comparing the readings of different people on the same water, and making sure that the observers whose records are relied upon have normal eyes and secure results approximately the same as those of other people with good eyesight.

The method of measuring turbidity proposed by the author is certainly a most interesting one, and I hope it will be investigated and compared with some of the other methods about which we know so much.

MR. F. N. CONNET.† Perhaps there are some others in the room who, like myself, once knew what a Nicol's prism is, but have forgotten. My recollection is that it is a polarizing instrument, but I am not quite sure of that. If there is anybody in the room who can explain it, I think it would be interesting to have it explained.

MR. C. W. SHERMAN.‡ Mr. President, I will not attempt to give a scientific explanation of it, for my recollection is nearly as dim as

* See paper, "The Physical Properties of Water," to appear in the next issue of the JOURNAL. — ED.

† Mechanical Engineer, Builders Iron Foundry.

‡ Assistant Engineer, Metropolitan Water Works, Boston, Mass.

Mr. Connet's. I do not remember what the material of the Nicol's prism is, but I know it polarizes light, and with two Nicol's prisms, setting the planes of polarization at right angles one to the other, the polarized light can be entirely obscured. By a rotation, such that the plane of one prism will be at right angles with the plane of the other, the obscuration of light passing through the tube containing the first Nicol's prism would be complete, while with the planes parallel the light would be transmitted without obscuration.

That suggests a possible lack of sensitiveness in the use of this instrument, since there is only a ninety-degree angle of rotation from total illumination to total obscuration; reading on the silica standard of water, as we do on our Metropolitan supply, — where we read gradations of turbidity varying from two or three points at ordinary times to more than a hundred when the streams are in freshet, — and with the muddy waters of the West, they may go, for all I know, to a thousand; it would be decidedly difficult to read all the gradations that one might want in ninety degrees of rotation.

It seems to me that Mr. Anthony in devising this instrument has apparently gotten hold of a similar idea — not in making use of polarized light, but in the construction of the instrument — to that of the FitzGerald and Foss colorimeter which has been used for something over ten years on the Boston and Metropolitan Water Works, and which was described to this Association by Dr. Frederick S. Hollis three or four years ago.* That instrument consists of two parallel tubes, in one of which the water to be examined is placed to a standard depth, and into the other of which platinum and cobalt standard is forced by means of a bulb to a varying depth, until the colors are matched in an eyepiece constructed to show light from both tubes at once in the same way that Mr. Anthony's would do. It is, however, not a turbidimeter. I should judge that Mr. Anthony had not known of this colorimeter, because he does not mention it, although he lists color determinations as well as turbidity determinations proper in the methods which he states have been used with the intention of estimating turbidity.

I think perhaps Mr. Anthony was fully cognizant, or, at least, more fully cognizant of the difference between turbidity and color than Mr. Hazen infers, since he states, after listing these methods, that several of them are simply measures of color; but I think it is undoubtedly a fact, and probably that is what Mr. Anthony intended to convey, that

* JOURNAL, Vol. XIII, p. 94.

some of these methods have been used with the intention of estimating turbidity, although they are properly merely measures of color.

MR. ANTHONY (by letter). In answer to Mr. Hazen's remarks I would observe that his new method of graduating the platinum wire turbidimeter had not been made public by the United States Geological Survey at the time my communication was prepared. Though this method is a distinct improvement on the original arbitrary one, I may point out that it is put forward as a tentative one, subject to alteration, and that it does not overcome errors due to differences in observers or in observing conditions.

The instrument I suggest would, of course, as Mr. Sherman points out, have a range embraced within a rotation of ninety degrees, seeing that the intensity of the transmitted light varies as the square of the sine of the angle comprised between the principal plane of the Nicol's prism and the plane of polorization. But this does not constitute a limitation of the instrument, as any degree of obscuration from perfect transparency to absolute opacity can be read upon the disc, if this is properly graduated over an arc of ninety degrees, to a rational scale on the basis of the above well-known law connecting the rotation with the percentage of light transmitted.

I must thank Mr. Sherman for recognizing that I was perfectly cognizant of the difference between determinations of turbidity and color, and that I only mentioned many of the methods employed with the object of showing that they had been improperly used.

I had not before heard of the colorimeter mentioned by him, but I have since read an account of it by Dr. Hollis in his paper on "Methods for the Determination of Color, and the Relation of the Color to the Character of the Water."

It is in no sense a turbidimeter, but simply an instrument for carrying out comparisons with any existing or other fluid standards rapidly and accurately, by varying the thickness of the latter. For this purpose it is the most ingenious and practical piece of apparatus I have yet seen described. The arrangement by which the light from two sources is brought into the same field of view only differs from that employed in my instrument in that two Nachet prisms take the place of one Wenham prism.

It will be seen that it thus in no sense trenches on the functions of the latter instrument, which has as an object the establishment of an absolute and rational photometric scale for turbidity estimates.

REPORT OF THE COMMITTEE ON UNIFORM STATISTICS.

[*Presented September 11, 1902.*]

BOSTON, September 10, 1902.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION: —

Your Committee on Uniform Statistics presents the following report: —

During the year a considerable progress has been made in uniform water-works statistics. Perhaps the most important gain has been the adoption by the American Water Works Association and by the Central States Water Works Association of our form for summarizing statistics, so that all the water-works associations of this country have now adopted, and recommend their members to use, a single standard form.*

We are also pleased to report an increase in the number of water works reporting statistics in accordance with the standard summary, and greater uniformity in following the standard form. This appears to be the result of sending out blanks containing the headings of the standard summary.

The form endorsed nearly a year ago, which is a slight modification of the first form adopted by the Association, has proved generally satisfactory. We would, however, recommend a few slight changes, principally in the arrangement of items. The most important change proposed is the consolidation of the financial items into one table, instead of having separate tables for maintenance and construction, as heretofore. All the items of the summary as now used would be retained, and two or three new ones added; and it is believed that a seeker for information would be able to find the items he desired to use more easily in the proposed arrangement than in the one now in use. The proposed grouping is also in line, in a general way, with the scheme of the National Municipal League, and is thus a step towards uniformity with other societies.

The proposed new arrangement of the Financial Statistics, which was suggested by President Merrill, is as follows: —

* Since the above report was presented, the American Society of Municipal Improvements has also adopted the New England Water Works Association form. — ED.

FINANCIAL STATISTICS.

RECEIPTS.

Balance brought forward:

(*a*) From ordinary (maintenance) receipts, $ ....

(*b*) From extraordinary receipts (bonds, etc.), ...

Total, $ ....

From Water Rates.

A. Fixture rates, $ ....

B. Meter rates, ...

C. Total from consumers, $ ....

D. For hydrants, $ ....

E. For fountains, ...

F. For street watering, ...

G. For pub. b'ld'ngs, ...

H. For miscel. uses, ...

I. Gen'l approp'n, ...

J. Total from municipal depts., ...

K. From tax levy, ...

L. From bond issue, ...

M. From other sources:

.................................., $ ....

.................................., $ ....

N. Total, $ ....

EXPENDITURES.

Water Works Maintenance:

AA. Operation (management and repairs), $ ....

BB. Special:

....

.................................., ...

CC. Total maintenance, $ ....

DD. Interest on bonds, ...

(CC + DD), ...

EE. Payment of bonds, ...

FF. Sinking Fund, ...

Water Works Construction:

GG. Extension of mains, $ ....

HH. Extension of services, ...

II. Extension of meters, ...

JJ. Special:

....

....

...., ...

KK. Total construction, ...

LL. Unclassified expenses:

.................................., ...

.................................., ...

MM. Balance:

(*aa*) Ordinary, $ ....

(*bb*) Extraordinary, ...

Total balance, ...

N. Total, $ ....

Disposition of balance, ...

O. Net cost of works to date . . . . $ ....

P. Bonded debt at date . . . . $ ....

Q. Value of Sinking Fund at date . . . . . . $ ....

R. Average rate of interest, ... per cent.

Under the general heading of "Pumping" in the present form are two items, based on "Cost of pumping figured on total maintenance," reduced to "cost per million gallons" and to "cost per million gallons raised one foot." Being computed on the total expense of maintenance, this is not properly the cost of pumping, but rather the cost of supplying water, and should be applicable to gravity supplies as well as to pumping works. We therefore recommend that the items be transferred from Pumping Statistics to Statistics of Consumption of Water; that the cost per million gallons raised one foot (which would not apply to gravity works) be omitted, and that the two items appear as "Cost of supplying water, per million gallons, based on total maintenance (CC)," and "Cost of supplying water per million gallons, based on total maintenance, (CC) + interest on bonds (DD)." The former item should admit of comparisons between various works, while the latter, being dependent on the amount of bonds outstanding, would simply show the actual cost of supplying water under the particular circumstances.

When the Committee was continued at the last annual meeting, it was suggested that a form for summarizing statistics of purification works might be prepared and added to our present summary. Such a standard form seems very desirable, as there is at present a great lack of uniformity in the statistics kept at various purification works, and, indeed, at some very few data are kept. We have commenced the preparation of such a form, but there still remains a considerable amount of work to be done on it. We suggest that the Association authorize us, after preparing such a form, to give it a trial on several purification works before actually reporting it to the Association. This would not constitute an adoption of the form by the Association, but would enable us, at the next convention, to report with the form the results of its actual trial.

In brief, then, we report: —

First. A substantial gain in the adoption and use of our standard form of summary by the other water works associations and by water works.

Second. A recommendation of the adoption by the Association of a few slight changes in the standard form.

Third. Requesting authority to make trial use of the form for summarizing purification statistics which we now have in preparation

before reporting it to the Association, the result of the test, together with the form recommended, to be reported to the next convention.

Respectfully submitted,

JOSEPH E. BEALS,
GEO. F. CHACE,
J. C. WHITNEY,
M. N. BAKER,
CHARLES W. SHERMAN,
Committee on Uniform Statistics.

DISCUSSION.

THE PRESIDENT. Gentlemen, the report of the committee is now before you. We have with us this afternoon a gentleman who takes a great deal of interest in the subject of municipal accounting, and who, through his office as secretary of the Boston Statistics Department, and also as chairman of the Committee on Municipal Accounts and Statistics of the National Municipal League, is very well qualified to speak to us. I will call upon Dr. E. M. Hartwell to address us at this time.

DR. HARTWELL. *Mr. Chairman and Gentlemen of the Association,* — Perhaps I ought to explain my position. I came in here to hear the report of your committee, not expecting to speak. I do not wish to be taken for one who turns up wherever there is a chance to talk. I am reminded of an old black bath woman, an expert in a way on water matters, who had charge of the ladies' bath room at the White Sulphur Springs in Virginia. Her patience was somewhat tried by the ladies who were reluctant to bathe in her presence, and to such she used to say: "Don' you min' me, honey; it ain't no treat for me." [Laughter.] So while I am really interested in this subject I don't like to be thought too pleased at being called up to speak on it. That being understood, I am glad to express my thanks for the opportunity to tell you how this report has interested me. The report shows that the experience of your committee has been similar to that of the committee of the National Municipal League charged with the duty of drawing up schedules for the promotion of uniform municipal accounting and uniform municipal statistics. Our committee, like yours, has proceeded deliberately, and has asked to be continued so that we may test our schedules before recommending

their final adoption. It strengthens my confidence in our method of procedure to find that your method is of the same nature.

In general, the object of our committee is to establish a set of schedules to conform to the provisions of the municipal program of the National Municipal League, which was issued in 1899. In effect, the municipal program is a Municipal Corporations Act, intended to apply to all the cities in a given state, and to secure uniformity in administrative methods in the government of such cities. The legislature of Ohio has recently voted to establish a system of uniform municipal accounting, and is now considering the adoption of a general municipal act. The municipal program provides that the financial statistics of all cities, and the reports of city auditors or comptrollers, shall be made annually to a central office of control, for example, the state comptroller, in accordance with forms prescribed by the central office. Primarily our problem was to devise a set of schedules to conform to that scheme; at the same time we have sought to produce certain schedules which could be made use of now, inasmuch as for several years the Department of Labor at Washington has been called on under an Act of Congress to publish statistical tables relating to the financial operations of some one hundred and thirty cities of the United States. It is perfectly evident from a study of those tables that it is far from easy to reduce the material on which they are based to a common standard. Our committee, which has been at work for two years, has made two provisional reports, one at the Rochester meeting a year ago and a second at the recent meeting of the National Municipal League in Boston. Possibly we may be able to make a final report in May, 1903.

We have been fortunate in securing the experimental adoption of the principal schedule recommended in our report at Rochester. Thus the report of the auditor of Newton, Mass., for 1900, the report of the comptroller of Baltimore for 1901, and the reports of Mr. Harvey S. Chase (who is a member of our committee) on "The Accounts of Brookline, Mass., for 1901," and on the "Receipts, Appropriations and Expenditures of Boston for 1901," all contain a summary statement of receipts and expenditures drawn up in accordance with that schedule. Furthermore, the new scheme of bookkeeping and a new form of comptroller's report adopted by the city of Chicago at the instance of Messrs. Haskins & Sells, expert accountants of New York City, contain features recommended by our committee, of which Mr. Haskins is a member.

The Boston Statistics Department, of which I happen to be secretary, has published a study of Boston's receipts and expenditures for the fiscal year 1900–1901, consisting of seven tables based on the schedules recommended by our committee. You will find it published in Volume IV, No. 6, of the monthly "*Bulletin of Statistics*," of which I have a copy here.

In our second report to the National Municipal League, which is now in press, we have recommended a set of schedules embodying certain modifications suggested by the experience gained through testing the practicability of the schedules appended to our first report.

The two most characteristic features of our scheme are, (1) the separation of ordinary or maintenance and extraordinary or capital receipts and expenditures, and (2) the grouping of departmental receipts and expenditures under certain general heads, according to function; that is, General Government, Public Safety, — including Police, Fire, Health Departments, etc., — Public Works, Public Education, Recreation, and Art, etc. But I will not weary you by going further into the details of the scheme upon which we are still at work.

In the interesting report which your committee has just presented, the point has been made that the proposed statement conformed in general with the scheme of the National Municipal League — so it does. Yours is a consolidated statement showing ordinary (maintenance) receipts and expenditures on the one hand and extraordinary or construction (capital) receipts and expenditures on the other. If I may be allowed a suggestion, I would say that if the balance brought forward were divided to show how much was derived from ordinary and how much from extraordinary receipts, and the balance carried forward were similarly divided to show what was destined for the maintenance and construction accounts respectively, the schedule would conform very completely with our own. At least, that is my impression from such examination as I have been enabled to make through the courtesy of your committee.*

Thus far the committee of the National Municipal League has devoted itself mainly to the consideration of financial statistics. During the next twelvemonth we shall attempt to deal, to some extent, with other branches of municipal statistics, though we are well aware that in many branches chaos reigns at present. I devoutly wish there were a larger number of associations like this, — made up

* This was done in the form submitted, although the change had not been made in the copy shown to Dr. Hartwell. — ED.

of men trained in the application of scientific rules and formulæ. If there were, the collection and presentation of statistical data in respect to important and interesting forms of municipal activity would yield much more satisfactory results than is usually the case.

There is no lack of people anxious and ready to compare cities with each other in respect to death rate, the per capita cost of parks, of charities and correction, fire protection, water supply, and the like. But such comparisons are apt to be misleading, because of the difficulty of securing an accurate standard of comparison.

Even in the comparatively simple matter of death rates, comparative statistics are open to grave suspicion, because the estimates of population in intercensal years are so often vitiated by guesswork and vainglory. I need not urge the need of scientific methods in estimating population upon you who have to estimate the growth of population as a basis for forecasting the future needs of your cities with regard to water works, sewers, etc.

I shall content myself with citing a single illustration.

Some years ago an elaborate and interesting paper comparing the principal cities of the country with respect to taxation, the cost of public works, etc., was presented at the meeting of the American Society of Municipal Improvements. The writer gave the population of Baltimore as 500 000 by "official estimate," for the year 1898. A few months later an article appeared in the *Charities Review*, in which Baltimore was compared with other cities in respect to the per capita expenditures for outdoor relief of the poor, and the population of Baltimore for 1898 was officially estimated (so the writer said) at 625 270. At the same time the Baltimore Board of Health calculated the death rates for 1898 on the basis of a population of 541 000.

I asked the health officer how he got his figure. He said, "Independently, on the same day, I sent to the two principal newspapers of the city and asked what their estimate of the population of Baltimore was. One said 540 000, the other 541 000, and I took 541 000." The United States Census in 1900 found a population of only 508 957. If in comparing cities in respect to the death rate, per capita cost of public works, and poor relief, the standard for a given year varies between 500 000 and 625 000 of population, we may well consider such comparisons as scarcely worth the paper that they are printed on.

Mr. F. H. Crandall. Mr. President, I move that the report of

the Committee on Uniform Statistics be accepted and adopted. By that I mean that their request and recommendations are endorsed by the Association.

(Mr. Crandall's motion is adopted.)

TWENTY YEARS AFTER. — A RETROSPECT.

BY ROBERT C. P. COGGESHALL, SUPERINTENDENT OF WATER WORKS, NEW BEDFORD, MASS.

[*Read September 11, 1902.*]

About two weeks since, I received a telephone message from the Secretary of this Association, asking if I would prepare remarks upon the topic which heads this paper, the same to be presented at this meeting. Finding that he had been disappointed in other directions in obtaining material for the program, I reluctantly consented.

I know that you would have been interested in a well-prepared review of the literary work contributed by the members of this Association since the date of its inception, over twenty years ago; but the time has been too brief for any attempt in that direction, and as most of you are familiar with the material which has been published, I shall have little to say touching that phase of the matter. I hope, however, to interest you in a sketch of reminiscences mainly drawn from the history of the Association from its earliest period down to the establishment of the JOURNAL in 1886.

The first question which may be asked is, "Who was the first to suggest an organization of this character?"

My reply is, James W. Lyon, then superintendent at Salem, Mass. While this story has hitherto been told, it never yet has appeared in the official publication of this Association, so it seems fitting that it should now be recorded.

As early as 1877 we find Mr. Lyon discussing the matter with neighboring superintendents. His idea then was the formation of a national association. He succeeded in arousing considerable interest, but his work did not immediately result in further development. During the next two years Mr. Lyon talked with every water-works official he happened to meet regarding the project. In March, 1879, he was induced to prepare a circular letter, which he mailed to every known water department in the United States and Canada.

The following is a copy of that circular: —

SUPERINTENDENT'S OFFICE, SALEM WATER WORKS,
SALEM, MASS., March 15, 1879.

Dear Sir,—Having for some time thought that the superintendents of water works throughout the country should have some way of becoming better acquainted with each other, and that it would be both pleasant and beneficial to all to have some kind of an organization and to meet in convention occasionally, to exchange ideas for the better management of the great interests we represent, I have ventured to propose the following questions to the superintendents and managing engineers of this country and the provinces.

First. Do you think it desirable to have such an organization?

Second. Is the project feasible?

Third. At what time of the year would it be best to hold the convention?

Fourth. Where is the best place to hold it?

Fifth. Would you probably attend such a convention?

Please answer, and add any suggestions that may tend to bring the subject in good shape before the fraternity.

Please address,

JAMES W. LYON,
Superintendent Water Works, Salem, Mass.

Mr. Lyon, in an address as President of this Association to the Worcester Convention in 1883, stated that four hundred copies of the circular were sent to various parts of the country, from which only seventy replies were received. He adds: —

"Of this small number there were those who thought the object a good one."

"Others replied that it was too comprehensive in taking in the whole country."

"There were others who thought that there was no need of such an organization."

"The lack of enthusiasm exhibited, together with the pressure of private interests, caused the abandonment of the project, although it was certain that if the project were carried into effect great good was sure to be the result."

A few years ago Mr. Holden, of Nashua, happened to meet Mr. Lyon at a Chicago convention of the American Water Works Association. At that time Mr. Lyon gave him a package of letters, which I now place before you to be deposited in the files of this Association. They are the replies which Mr. Lyon received in response to his circular. In looking them through I fail to understand how Mr. Lyon reached the conclusion stated, for to me they appear full of encouragement. It seems to me that if Mr. Lyon had

possessed more of the qualities of leadership, he would have experienced no trouble in effecting an organization at that time.

Let us briefly analyze these replies. The package contains fifty-six letters. Thirty-three are from localities outside of New England, almost every state east of the Mississippi River being represented. All are in sympathy with the project, and, with few exceptions, agree to be present at the first meeting. The range of location suggested for the first meeting was large. About one-half favored a "central location," most convenient to the largest number. There was the largest possible variation in ideas regarding the time, nearly an equal number favoring each season of the year.

One reply is worthy of reproduction. It is from one who later became prominent in the organization of this Association, and has remained one of its best known and strongest members. The language will be recognized as characteristic. He says: "I never have seen any superintendent but what I could learn something from, and any meeting of the kind you speak of would be a benefit to me; but as I might go to a convention of that kind to-day and have my head cut off to-morrow, I shall keep out. I will do my best to entertain any superintendent that may come here, and then I shall get the best of it, for if he is any way social he will be APT to tell me something that will be a benefit."

It is said that a wise man may change his mind. This is true in this case, for we all know that our dear friend Charles K. Walker, who wrote those lines, is lacking in neither wisdom nor good common sense. It is needless to say that he did not keep out, neither has he ever had his official head cut off.

In a few replies there appears the suggestion that it might be well to organize upon lines of limited territory. New England then contained one hundred and fourteen water departments. That territory might be the field of the work of one society, the Middle States of another, and so on. Then later a national society might be organized, of which the local societies would become branches.

Included in this list of replies were letters from W. L. Cameron, of Memphis, Tenn.; Ira A. Holly, of Burlington, Ia.; M. Donahue, of Davenport, Ia., and W. C. Stripe, of Keokuk, Ia. The enthusiasm of these gentlemen, once aroused, was not to be quenched. They heartily believed that the time was ripe for the organization of an association as proposed by Mr. Lyon's circular, and later we find them all prominently identified in the organization of the American

Water Works Association, which occurred at St. Louis, on March 21, 1881. W. C. Stripe took upon himself the responsibility of issuing the call for that gathering.

J. C. Briggs, of Terre Haute, Ind., took an active part in this organization. He was an enthusiast, as was shown a few months later, when we find him visiting several of the New England cities, and endeavoring by personal interviews to interest the department officials in the work so successfully inaugurated. His efforts were not fruitless. Interest in the project was easily secured, but the means of meeting the necessary expense in attending a convention at a distant center were not so clear to many. Indeed this phase of the question yet remains a serious obstacle to many in the attendance of our own conventions.

Such was the condition of affairs when three superintendents happened to meet, one bright winter's day, at Lowell, Mass. No previous appointment had been made; it simply happened by chance. On February 17, 1882, the writer took occasion to go to Lowell to acquaint himself with the inspection methods of the department of that city. For the first time he met Horace G. Holden, who then was the Lowell superintendent. During the morning Frank E. Hall, then in charge of the Worcester Water Works, called, on a friendly visit. Thus three officials met for the first time, all strangers to one another previous to that interview, but the friendships then formed developed into closer relationship with the passing years.

That day, while sitting around the dinner table at the Merrimac House, Mr. Holden called attention to Mr. Lyon's earlier efforts, and also to Mr. Briggs' more recent interviews in behalf of the American Association. A long discussion seemed to make clear the fact that New England offered a particularly good field for a helpful organization. While all were in sympathy with the work of the American Association, it seemed evident that the conditions and practices of the New England departments differed considerably from those of other regions of the United States. There was also the fact that there were such a large number of departments in a comparatively small territory that almost any of its centers were but a short distance from several water works. Thus several single-day meetings could be held in the course of the year, at which a good attendance could be secured, without much loss of time or burdensome expense on the part of the attendant. Such was the conclusion to which this discussion led, and after the dinner it was thought best

to attempt to enlist the interest of Henry W. Rogers, then superintendent at Lawrence, Mass. Accordingly Mr. Hall and the writer proceeded to Lawrence. Mr. Rogers had met Mr. Briggs, and was easily interested. It was agreed that the four gentlemen (Holden, Hall, Rogers, and Coggeshall) should constitute a self-appointed committee. Their first act was to write Mr. Lyon asking him to become a member of this committee and help in the work, to which he consented. The territory of New England was then divided into five districts, and each member of this committee took one of the districts for correspondence with the department officials located therein. All went to work, and a month later a comparison of returns was made. The success of the scheme seemed assured. The committee then decided to invite all interested parties within their districts to be present at a general meeting, to be held on April 19. I herewith present to the Association the original letter written by me at that time, from which the hectograph copies which were sent out were made.

OFFICE OF NEW BEDFORD WATER WORKS.
CITY HALL.
R. C. P. COGGESHALL, Supt. New Bedford, Mass., March 16th 1882

There is a movement being made to form an association of the water works managers of New England. This movement is endorsed by Mr Lyons of Salem, (who was the first to suggest the formation of such an organization) Mr. Holden of Lowell, Mr. Hall of Worcester, Mr. Rogers of Lawrence and others. This association is to meet once or twice a year in convention and exchange ideas. No doubt much profit as well as pleasure will be derived from these proposed gatherings. In order that the organization may be an assured success it is both necessary and important that there be a large attendance at a preliminary meeting which will be held on Wednesday April 19th. The place of this meeting will be decided later, it will probably be Boston or vicinity. I am requested in the name of the informal committee mentioned above to extend an invitation to you to join the movement and to be present at the above named preliminary meeting. It is hoped that there will be a large representation of Registrars, Clerks, &c as well as Superintendents. Should you find yourself interested we hope you will lend your influence by extending an invitation to be present at the preliminary meeting to all those whom you think would be interested.

Can you make it convenient to attend this preliminary meeting. If you wish I will advise you of the place of meeting as soon as it is decided

Yours truly

R. C. P. Coggeshall

FACSIMILE OF CALL FOR FIRST MEETING.

PLATE I.

JAMES W. LYON,

First President of the New England Water Works Association,
1882–1883.

The suggested meeting materialized at Young's Hotel, Boston, on April 19, 1882. There were nineteen officials present, besides other gentlemen. As many will be interested to know just who were there, I give the list: —

Thomas C. Lovell, Fitchburg, Mass.
Joseph C. Hancock, Springfield, Mass.
Frank E. Hall, Worcester, Mass.
A. H. Martine, Fall River, Mass.
W. F. Cleveland, Brockton, Mass.
R. W. Bagnell, Plymouth, Mass.
Edwin Darling, Pawtucket, R. I.
Charles K. Walker, Manchester, N. H.
Henry W. Rogers, Lawrence, Mass.
Hiram Nevons, Cambridge, Mass.
Horace G. Holden, Lowell, Mass.
J. G. Tenney, Leominster, Mass.
S. E. Grannis, New Haven, Conn.
W. W. Hawkes, Malden, Mass.
Robert M. Gow, Medford, Mass.
James W. Lyon, Salem, Mass.
Robert C. P. Coggeshall, New Bedford, Mass.
James H. Hathaway, New Bedford, Mass.
J. J. Whipple, Brockton, Mass.
John L. Harrington, Cambridge, Mass.
W. W. Cross, Brockton, Mass.

Also present were: —

John C. Kelley, President National Meter Co., New York.
Lewis H. Nash, M. E., Inventor Crown Meter.
C. C. Cowpland, Agent Davidson Steam Pump Co.
Ex-Gov. James A. Weston, of Manchester, N. H.

Mr. Lyon was elected temporary chairman and the writer temporary secretary. Messrs. Darling, of Pawtucket; Nevons, of Cambridge; Hall, of Worcester; Martine, of Fall River, and Walker, of Manchester, presented suggestions regarding the development of the plan of organization. Messrs. Darling, of Pawtucket; Grannis, of New Haven, and Nevons, of Cambridge, were appointed a committee to prepare the draft of a constitution and by-laws, the same to be submitted to an adjourned meeting.

An attempt was then made to start a "topical discussion," but no one seemed inclined to talk. Here was a body of nineteen strangers drawn together by a common interest, but with one or two exceptions all were unaccustomed to public speaking. More or less embarrass-

ment was evident. There occurred at this time an incident which did much in making every one feel more at ease. Charles K. Walker was describing his experiences with wrought-iron, cement-lined pipe. He had just declared that without the slightest provocation it would burst once in every fifteen minutes, and he was giving further vent to his feelings regarding it, when the door opened and a fine-looking, elderly gentleman appeared. Mr. Walker stopped his remarks and said something like this: —

"Gentlemen, I wish to introduce you one and all to my friend Ex-Governor Weston, of Manchester, N. H. He is deeply interested in our work. The governor and I started life together as boys, but brains will tell every time. He has risen to the high honor of being governor of New Hampshire while I remain a miserable superintendent of water works."

The characteristic tone in which these last words were uttered provoked shouts of laughter, and conversation became freer.

The adjourned meeting was held at Young's Hotel, Boston, on Wednesday, June 21, 1882. There were twenty-five officials present, Desmond FitzGerald, of the Boston Department, and Albert S. Glover, then water registrar of Newton, being among the newcomers. The committee appointed at the previous meeting presented the drafts of the Constitution and the By-laws. These were taken up in debate, a few changes made, and then adopted, after which the following officers were elected under the provisions of the constitution: —

President: James W. Lyon, Salem, Mass.

Vice-Presidents: Charles K. Walker, Manchester, N. H.; Hiram Nevons, Cambridge, Mass.; Edwin Darling, Pawtucket, R. I.; H. L. Schleiter, Meriden, Conn.

Secretary: R. C. P. Coggeshall, New Bedford, Mass.

Treasurer: Edwin Darling, Pawtucket, R. I.

Executive Committee: The above named, with Frank E. Hall, Worcester, Mass.; A. H. Martine, Fall River, Mass.; J. G. Tenney, Leominster, Mass.

Financial Committee: J. Warren Cotton, Cambridge, Mass.; Horace G. Holden, Lowell, Mass.; Phineas Sprague, Malden, Mass.

That was twenty years ago. It seems as if it were yesterday. Through memory's eye I see the space before me alive with the faces of those who were present and who since have joined the silent majority. There was Cotton, the genial registrar of Cambridge; Nevons, the able superintendent of the same city; Darling, the energetic superintendent of Pawtucket; Lyon, the first President of the Association,

PLATE II.

FRANK E. HALL,

President of the New England Water Works Association,

1883–1884.

and Rogers, the well-equipped but exceedingly modest superintendent of Lawrence. Then there were Schleiter, of Meriden, and Sprague, of Malden. All were prominent at that time, but now their voices are silent.

At a meeting held the following October, at Salem, there appeared for the first time the face of one of the sweetest characters I ever have met. He proved to be a strong addition to our forces, and was of great assistance in the early development of the Association. He later honored the Association by filling positions of trust, and finally he became its president for the year 1890–91. Of course I refer to Albert F. Noyes, whose tragic death in the Park Square Station, of this city, on October 12, 1896, we have never ceased to mourn.

The Association seems to have been slow in its development during the first year. The President, Mr. Lyon, was a large man, exceedingly amiable and having great interest in the work. But he was deliberate and ponderous in his mannerisms, and did not seem to possess the faculty of inspiring others. The writer was thoroughly "green" concerning best methods of conducting the secretary's work. So I always have thought that others possessing greater experience could have accomplished more that year than did we. One thing is certain, — the members became well acquainted with each other, so perhaps there was more of a solid foundation laid than at first sight appea .

At the second co ention, at Worcester, in 1883, Frank E. Hall was elected President, and he proved an admirable choice. At that time the member ip had reached forty-three. Not a large number, you will say, but the leaders of that day did not dream of a society of ambitious proportions, with its well-equipped accessories, as it now exists. Their ideas had rather the opposite trend, — a club of select membership, modest in numbers; the meetings to be more of the nature of social and informal gatherings, affording opportunities for the comparison and discussion of personal experiences.

Walter H. Richards, William R. Billings, George A. Ellis, and Charles H. Baldwin were present at this meeting, and took active parts in the proceedings. Later each of these gentlemen did an immense amount of work in our interest.

If you had been present at that convention you would have heard Darling (he was always energetic and positive in his discussions) maintaining that there were no hidden leaks upon his pipe system,

and that the only leaks that gave him trouble were those around the faucet. Nevons quickly took issue with this statement. He had given a great deal of attention to night inspection of the Cambridge pipe system, and had discovered many hidden leaks. Darling was an earnest advocate of the "meter" system, so he had the best of it when this question was considered, while Nevons hoped that the general application of meters to prevent waste of water would never come. He pleaded for a well-organized system of house-to-house inspection, which he thought would be more effective. In later years he was converted from that opinion, in company with many others.

The following fall the Association was entertained at Pawtucket, R. I. After sight-seeing about the town, a steamboat was taken for one of the shore resorts down the bay, where an excellent clambake was served. Many of you will remember the fine display of fire streams which Darling made as the boat passed through the draw of the India Point Bridge. We all passed under an arch of living water.

The third annual convention was held in Lowell, Mass., on June 19 and 20, 1884. The officials had worked hard, and they were rewarded for their efforts in having a convention which showed advance in the quality of the papers presented. Two especially able papers were read, one by W. H. Richards, of New London, and the other by H. W. Rogers, of Lawrence. The former attracted considerable attention outside the ranks of the society, and has reappeared many times in various publications. It was at this convention that William B. Sherman, one of the most conscientious workers of our early years, unfolded his scheme for the exchange of sketches. His plan called for an agreement on the part of each member to bring to each annual convention a sufficient number of sketches of an idea or device to supply all other members who were prepared to exchange. Sherman worked hard in creating a sentiment in favor of this scheme, and for a number of years it was practiced quite successfully. But a few years bring many changes. A large proportion of the old membership drops out of sight, and a constantly increasing number of new individuals join the ranks. The idea did not appeal with sufficient force to the newcomers to induce them to continue the work. It therefore gradually dwindled. Finally there came a meeting at which very few sketches appeared, and the scheme was then dropped. If our membership only could realize what an im-

PLATE III.

GEORGE A. ELLIS,

President of the New England Water Works Association,
1884–1885.

mense amount of information could be imparted by this simple process, they would not have allowed the practice of Sherman's most excellent scheme to have faded completely out of sight.

No one present at this meeting will ever forget the wonderful hydraulic display which occurred while the morning session was being held in the parlor of the St. Charles Hotel. An unusually severe thunderstorm occurred, which broke up the meeting. Presently a horseless carriage appeared upon the street and passed the hotel. There was no driver to guide its course. It moved very like an automobile. It was propelled by the power of the violent wind and rain. Whence it came or whither it went we never knew. Neither can we forget the good-natured bantering which occurred later in the day at Tyng's Island, between Col. A. A. Hagget, of Lowell, and Charles F. Chickering, of Pawtucket, R. I. And also we remember our worthy member who lost his hat, and his frantic attempts to regain the same, directly in front of Mayor Donovan, who then was addressing the convention in the dining-room of the St. Charles Hotel. Among the new faces which appeared at this meeting were those of George E. Batchelder and Lucian A. Taylor, both of Worcester.

At this convention George A. Ellis, then city engineer and water registrar of Springfield, was elected President. Mr. Ellis had secured an excellent reputation throughout the country by reason of his original work in hydraulic investigation. You are all familiar with his little book relating to the flow of water in pipes and fire streams. It then had been recently published. He was very prominent in our affairs during the period of which I now am writing. Shortly after, his professional work called him to a distant part of the country, and we were the losers thereby. At the same meeting Albert S. Glover, then water registrar of Newton, superseded the writer as Secretary. With these two able pilots at the helm, the Association made a rapid advance, and the next year occurred the most brilliant social event which this society has ever witnessed.

During the following fall the Association was entertained by the city of Newton, with sightseeing during the day and a banquet at Hotel Vendome, Boston, in the evening.

The following year occurred the joint meeting of this Association with the American Water Works Association, which held its annual session at Young's Hotel, Boston, in April, 1885. Previously a committee had been appointed to arrange a program of entertain-

ment for the visiting delegates of the American Association. The members of this committee were, Frank E. Hall, chairman; Albert S. Glover, secretary; J. Henry Brown; A. H. Howland; Albert F. Noyes; Wilbur D. Fiske; Jason Giles, and Charles H. Baldwin. While each member should receive a full share of the credit due the committee, I wish to make special mention of two of these names, because the committee was saved the embarrassment of planning in the dark by reason of their personal guarantee to raise the financial means necessary for the execution of the scheme. I refer to Jason Giles, who was the manager of the Chapman Valve Manufacturing Company, and Wilbur D. Fiske, who was agent for the George F. Blake Pump Company. Both were greatly interested in the welfare of the Association in those days, and did much personal work in promoting its interests. Fiske was a great joker. He possessed a most vigorous activity, and was always sure to have a crowd around him. Unusual demonstrations of merriment could always be heard when he appeared upon the scene.

The committee succeeded in collecting a fund of nearly twenty-five hundred dollars, all of which was expended in the execution of a well-planned program of entertainment. I don't ever remember passing a week in which every detail of a printed schedule was better executed. It was a continuous succession of festivities, and I remember that one of our best-known members afterwards told me that for two weeks after the close of the convention he had difficulty in keeping awake all day. It certainly was a most enjoyable week for all of us, and I think it was equally so for the visitors whom we entertained. Colonel Gardiner, of New Orleans, was the president of the American Association at this time, and J. H. Decker was secretary. They were very happy men during that week, and so were all of us. At the close of the convention Peter Milne, of Brooklyn, succeeded Gardiner as president of the American Association. Later he became secretary, which position he held until his death a few months ago.

The visiting delegates to the convention came as strangers to most of us. They returned to their homes with a host of new friends, and there are many strong ties of friendship to-day which date their origin from the time of this gathering.

The entertainment program included visits to places of interest, sometimes two or more parties going in different directions, and all in perfect harmony. The star event of the occasion, however, was the

PLATE IV.

Photo. 1902

ROBERT C. P. COGGESHALL,

President of the New England Water Works Association,
1885–1886.

"Duty Test of the American Water Works Association by the New England Water Works Association." It seems that Colonel Gardiner had asked in open convention in a previous year, "What is perfect duty?" referring, of course, to pumping engines. This test was in answer to his question, but on rather different lines from those to which his inquiry had been directed. If any pump had been necessary upon that occasion it would have been a stomach pump, for cases in which Nature had failed to perform her functions.

The menu was printed in an elaborate portfolio containing many technical phrases used during boiler tests, and illustrated with humorous sketches. The frontispiece of the menu was adorned with the motto, "'What is perfect duty?' L. H. Gardiner." I believe that the conclusion reached by this duty trial was that it consisted in attending to business, as exemplified by the illustrations on one side of the menu, and in not forgetting the good things of life as shown upon the remaining pages.

This elaborate function was held at Young's Hotel on the evening of April 21, 1885. It was elaborate in every sense of the word. The food, music, flowers, and the speaking which followed were all of superior quality. It was long after midnight when the benediction was pronounced. Quite a number of us had adjoining rooms which opened into each other. Of course we had to talk the event all over. About this time Fiske appeared with two colored individuals carrying pails containing liquid refreshments packed in ice. He was accompanied by another member, who proceeded to give us an astonishing dissertation on pipe laying. How we laughed! He was very lengthy, and we were both glad and frightened when he finished and left us, — glad that the end had come, and frightened at the way in which he went down stairs. As Fiske afterwards expressed it, the sound was similar to that caused by a large safe sliding down stairs and striking the floor below.

Glover had arranged to secure a fine report of that "Duty Test" banquet. You can imagine his consternation a few days later when he found that the reporter had lost every scrap of his notes concerning the event. Glover then went to work. He collected every newspaper report obtainable, and then with the aid of different memories the report was written as it now appears in the transactions of 1885. This episode, however, proved to be a blessing in disguise. More care was hereafter exercised in the selection of a reporter. This resulted in the discovery of Mr. James P. Bacon,

who sits before me, and who from that day to this has been constant in our service. His work, to say the least, has always been extremely satisfactory. A meeting of the Association would hardly seem complete without his presence.

In the long list of candidates who were elected members at this time the following names appear: William F. Codd, Dexter Brackett, Willard Kent, Wilbur F. Learned, F. H. Parker, and George A. Stacy.

Two months later (June, 1885) the fourth annual convention was held at Springfield, Mass. The writer succeeded George A. Ellis as President, and Albert S. Glover continued as Secretary. At this meeting Albert F. Noyes presented an elaborate paper on cast-iron pipe, and a lively discussion followed. This subject has been a perennial source of discussion from that day to this. The same may be said concerning "Service Pipe." Whenever short of material for our programs the introduction of either of these topics has been sure to provoke interesting debate.

At this same convention Mr. Billings and the writer presented a plan to secure uniformity in the presentation of the annual reports. This is another topic which has attracted considerable attention ever since.

Other papers presented were: "Relating to the Use of Tanks in Supplying Water-closets and Hot-water Boilers," by William R. Billings, and "Flushing Street Mains," by J. Henry Brown.

The most important act which occurred during the writer's administration was the development of the plan of the quarterly JOURNAL in its present form. It was Glover who conceived the idea, and I well remember when he first unfolded his plan and displayed figures to show that financially the scheme could be made a success.

The materialization of the plan for the publication of the JOURNAL required certain changes in the Constitution. This matter was referred to a committee who reported to the New Bedford convention in June, 1886, when the suggested changes were adopted. The positions of Senior and Junior Editors were created, and an increase in revenue was provided for by reëstablishing the status of the associate membership.

The first number of the JOURNAL appeared in September, 1886, and contained the proceedings of the New Bedford convention. It has continued to appear regularly each quarter up to the present time.

At the New Bedford convention more new faces appeared. There

PLATE V.

HENRY W. ROGERS,

President of the New England Water Works Association,
1886–1887.

were Patrick Kieran, Frank L. Fuller, Joseph E. Beals, M. M. Tidd, Phineas Ball, and William M. Hawes. The last three remain with us in memory only. Phineas Ball was a well-known pioneer water-works engineer, and a good one, too. He had been present at previous meetings, and now became a member of the Association. He had a genial and kindly nature, and made friends in every direction. I well remember the deep interest he took at that convention in the discussion which followed Desmond FitzGerald's excellent paper on "Rainfall." Mr. Ball and David B. Kempton, of my own city, were old friends (Mr. Kempton was a familiar figure at our conventions), and I used to enjoy hearing them rehearse former events.

M. M. Tidd you will remember as an accomplished engineer. He gave us all a great deal of inspiration and help. He had only one arm, and yet he was one of the best draftsmen I ever met.

William M. Hawes was the wit of the Association for many years. He was ready to discuss any question which came up. What a happy, jolly individual he was, and what faculty he possessed for putting every one about him in a good humor. How we sympathized with him in his long, painful illness, and when the end came we mourned his loss. When he made his bow to the Association at New Bedford, water meters were under discussion. He said that the perfect meter had not been invented; that he thought it would be like the perfect man, — just as he gets perfect he up and dies. The millenium will come with the perfect meter, and then we will have no use for it. He closed his remarks with the recital of a humorous poetical confession of a wicked water meter, which convulsed the whole audience.

At this convention, in addition to FitzGerald's "Rainfall" paper, George A. Ellis contributed a paper on "Discharge of Mains as Determined by Pressure Gages." Col. J. T. Fanning presented a paper on "Pumping Machinery," and Dexter Brackett, one on "Wastes of Water." Besides these there were many topical discussions.

The Association had its headquarters at the Parker House in New Bedford. After the evening session of the second day the rooms were filled by a crowd which was in no hurry to woo the sleepy god. A number being of a musical turn of mind took to singing the popular songs of the day. Perhaps to outsiders it sounded more noisy than musical. Anyhow it disturbed some of the inmates of the house, one of whom got up and sought the aid of a police officer

whom he found outside, surveying the windows from whence the sound issued. The disturbed lodger urged the officer to go in and stop what he termed an unmitigated nuisance.

"No, you don't," replied the officer, "I know my business. The mayor's in there."

The next day, upon the excursion boat, in passing down the bay you could have heard Fiske pointing out the old Revolutionary Fort Phœnix to the crowd, and endeavoring to convince them that it was there that Ethan Allen demanded the surrender in the name of the great Jehovah and the Continental Congress. Upon a protest being made by a member from Vermont to the effect that the event described had occurred near his home, Fiske replied, "Well, I'll postpone the rest of this story and continue it when we have a convention in Vermont."

At the closing session of the New Bedford convention, Henry W. Rogers became President, Albert S. Glover continued as Secretary, and William R. Billings and the writer assumed the duties of editors of the first issues of the JOURNAL.

The next year (1887) the annual convention was held at Manchester, N. H., at which place I resumed my former position as Secretary, which office I continued to fill until January, 1895. During this period the annual conventions were held in the following places: —

1888, Providence, R. I.
1889, Fall River, Mass.
1890, Portland, Me.
1891, Hartford, Conn.
1892, Holyoke, Mass.
1893, Worcester, Mass.
1894, Boston, Mass.

The Presidents with whom I served were: —

1887–88, Edwin Darling.
1888–89, Hiram Nevons.
1889–90, Dexter Brackett.
1890–91, Albert F. Noyes.
1891–92, Horace G. Holden.
1892–93, George F. Chace.
1893–94, George E. Batchelder.
1894–95, George A. Stacy.

The Senior Editors of the JOURNAL with whom I was associated were: —

Prof. George F. Swain, two years.
Desmond FitzGerald, one year.
F. H. Parker, one year.
Dexter Brackett, four years.

The Junior Editors were: —

William R. Billings, two years.
Albert S. Glover, two years.
Walter H. Richards, five years.

Brackett, Richards, Glover, and Billings all did an immense amount of detail work, and the Association profited by their conscientious efforts.

This Association had published over one hundred and fifty important papers up to the time I resigned the secretaryship in 1895. There had also been more than that number of topical discussions.

With the New Bedford convention, in 1886, I close this series of reminiscences. Many members of prominent standing, familiar to you all, have not been mentioned in this paper simply because their connection with the Association dates from a later period. The list is a very long one, and cannot with justice be lightly entered upon in a brief survey; so it appears better to refrain from any attempt at this time. There are those who have done what they could, and done it well, and the Association has been a gainer thereby. Proper credit should and will be ascribed to them in a future review of the period of time in which they worked.

One word regarding the JOURNAL. In 1893 a full index of all our previous publications was published. This was the work of Henry N. Ogden, C. E., and Dexter Brackett. It has occurred to me that the revision of that index up to and including the volume now in publication would be a production which would be appreciated by the frequent readers of our society publications.

I have heard the charge made that our Association has become more of an engineering club than a water works association, and that technical productions outweigh the practical. Is there any foundation for this statement? I think not; for I am not aware that the needs of the practical worker have ever been overlooked. That a larger number of practical papers would be acceptable goes without saying; but it is exceedingly difficult to induce the average practical worker to relate his experience. He likes to listen and absorb, but dislikes to talk; while on the other hand it is compara-

tively easy to secure the production of the well-trained student. This is the reason why it is difficult to always obtain a proper balance for an ideal program. We will all agree that the interests of the practical worker should be jealously guarded. He should be supplied with plenty of material each year. But the progressive worker cannot and will not stand still. You never knew a broad-minded practical worker of limited education but that he regretted his lack of technical training. Such a man is bound to press forward. He will absorb all he can, and the time soon arrives when his thoughts pass from elementary stages to more profound considerations.

Papers are occasionally presented the technical portion of which is too abstruse to secure the appreciation of the majority of our attendants. While such papers have their proper mission, it is better in the interest of best results that the speaker confine his remarks to limits within the range of all his listeners. We are very fortunate in having in our membership a few who rank high in their special work. They are constantly delving in pursuit of nature's secrets; and when rewarded by success in their undertakings, they come here and tell us about it in language so simple that every listener comprehends the truth that is uttered. No one ever complained that he could not understand every word of Prof. William T. Sedgwick's admirable addresses to this Association; and he always secures the delighted attention of the practical worker. The scientist that follows this plan is the true educator, and makes an ideal member of such a society as this. He interests the practical worker, and is sure to unconsciously influence his future thoughts. The worker in turn gladly aids him to new observations and the securing of data for new investigation. By such a process as this, the ideas of the worker will constantly aspire to higher standards.

In conclusion, the question may be asked, After twenty years, what? I think we can point with pride to the monument of literature which the members of this Association have gradually erected during these past twenty years. There it stands upon your shelves in almost as many volumes. No question is likely to arise in the practice of any official but that information pertaining to the same does not appear somewhere in its pages. Those volumes are among the best of reference books which every superintendent should have before him in his daily work. It needs no further encomiums. The work of its preparation has been done in the past by faithful and willing hands, and I am sure this will continue.

In considering the future of our Association from the present point of view, we see a well-equipped headquarters in Boston; the financial aspect in healthy condition; the absence of all jarring discord, and an interested membership who attend our meetings. As long as this condition continues it does not appear worth while to entertain any concern regarding what the future may have in store.

APPORTIONMENT OF CHARGES FOR PRIVATE FIRE PROTECTION AND THE MEANS OF CONTROLLING THE SUPPLY THERETO.

[*Reports of Committee and Discussion, September 11, 1902.*]

F. H. CRANDALL, C. K. WALKER, J. C. HAMMOND, JR., B. I. COOK, E. V. FRENCH, H. A. FISKE, AND JOHN C. CHASE, *Committee.*

The President called on Mr. Crandall for the Committee's report.

MR. F. H. CRANDALL.* As was understood when this Committee was appointed, Mr. President, some of its members held diametrically opposed views in regard to at least two of the matters involved, namely: First, as to who should pay the cost of private fire protection, and, second, as to the question of limiting the sizes of services permitted. We are obliged to report to-day that we are unable to agree, and probably never will be able to agree, on these two points. Three members of the Committee, Mr. Walker, Mr. Hammond, and myself, submit the following statement: —

Report of Messrs. Crandall, Walker, and Hammond.

Three members of your Committee, to whom was referred the matter of apportionment of charges for fire protection and means of controlling the supply thereto, would respectfully report that we find the opportunities for taking water without the knowledge of the water department, afforded by the presence of private fire pipes, are frequently taken advantage of; that furnishing private fire protection merits compensation; that the compensation, however, should not be such as to discourage the use of automatic sprinkler systems; that securing assurance of the use of private fire pipes for such purposes only is a matter of small expense and may reasonably be required.

We would recommend that, provided trustworthy evidence in regard to the use of the service and reasonable remuneration for the protection afforded be furnished, such applications for private fire services as will not nuwarrantably jeopardize other interests be granted.

MR. EDWARD V. FRENCH.† As Mr. Crandall says, our Committee have had different ideas, and we have not been able tc agree even on two reports. We have had a most interesting dis-

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* Superintendent of Water Works, Burlington, Vt.

† Inspector Associated Factory Mutual Insurance Co.'s, Boston, Mass.

cussion in the Committee, and those of us who differ from Mr. Crandall feel that he has gone just as far as he can in the matter with the view which he takes of the underlying principles of the whole thing, and we think he has shown a very excellent spirit in trying to get us together. I think if we had had more time, or, rather, if we had lived nearer each other so we could have had more frequent meetings, we could have agreed on some sort of a report; but, although we have had a great deal of correspondence, we have not succeeded in having meetings where we could all be present, except in one or two instances. I think we have never had a really full meeting, but we have discussed a good deal of matter which has been interesting, and I think we have all learned something; I am sure I have.

Our feeling was, then, that we could not do better, as long as we could not agree and as long as the matter had been deferred so many times, than to bring in our several ideas in the briefest form we could, and to say that in the most friendly spirit we had agreed to disagree and to put the facts before the convention and let the matter stand there. It may be that some further work can be done that will be of interest, and I think we are not very far apart now in the final result, our real difference coming in the fact that we feel that there is an underlying principle which gives a man a right to certain things, which Mr. Crandall and the other two gentlemen feel does not exist; and although the actual amount that Mr. Crandall wants to charge for the private fire service is small, and perhaps not appreciably larger than the user would be charged under the scheme that we have in mind, we felt that nothing was to be gained by covering up what seemed to us to be the elementary principles that underlie the whole thing, — questions of right and justice. And, as I say, our differences are wholly of a friendly nature and are wholly based on our different conceptions of the thing.

Now, we have put together a brief report which, if I may be allowed, I will read. This report is agreed to by Mr. Fiske, Mr. Cook, and myself. I think Mr. Chase will have something to say later which will show where he differs a little from all the rest of us. Our report is as follows: —

Report of Messrs. French, Cook, and Fiske.

Investigations and experiments made by your Committee have resulted in the following conclusions: —

First. Taking the country at large, water is taken somewhat frequently from private fire pipes for manufacturing and miscellaneous uses without the knowledge of the water departments.

The majority of such takings are not with deliberate intent to defraud the water department, but from a lax view of the rights in the case. Instances of intentional stealing, even to the extent of making concealed taps, are, however, not uncommon.

Second. Private fire protection is a benefit to the general public, because it greatly lessens the chances of a partial or total destruction of a prosperous manufacturing industry, which always means a loss of wages to operatives and sometimes a loss of the industry to the town. Further, fire allowed to gain headway in a large plant may spread and do great damage to surrounding property.

The effectiveness of private protection is largely due to the automatic sprinklers which cover every part, even to the most obscure corner, and stand ready night and day to put water on a fire the instant it starts.

Third. Water supply systems are almost universally laid out to furnish water for extinguishing fires as well as for domestic and manufacturing uses. A manufacturing concern, therefore, has a right to water without charge for extinguishing fires, the same as any other taxpayer. If then, the manufacturing concern puts in protection and desires to use public water in this private system for fire purposes because the public water can be used more effectively in this way, it is usually reasonable and right to allow it, providing absolute assurance is secured that water is not used for any other purpose. To allow this entails no extra cost to the public whatever, and absolutely lessens the calls which a plant makes on fire and water departments.

Fourth. Plants having private fire protection should pay all cost for such equipment, all the first cost for connecting to the public mains, and a yearly charge, ample to reimburse the public water department for all reasonable supervision of their fire pipes, such as to read and keep in repair any detecting devices which may be provided, and any other similar expenses.

Where a protected plant desires a better water supply than that furnished to the average taxpayer, considering relative values, it is right and proper that a part, if not all, of the cost of the additional mains needed should be paid for by the protected risk, the conditions in each case determining what is just.

Fifth. There are at present a number of ways by which assurance can be secured that private fire pipes are used for fire purposes only. It is considered that this branch of the investigation could be extended to advantage. The following methods have been examined with results as given:—

(*a*) Ordinary meters are not satisfactory from the possibility in many types of serious obstruction to the flow and from the fact that large size meters are frequently not sufficiently sensitive to detect the smaller drafts.

(*b*) Hydrants, sprinkler valves, and all other outlets of the fire system may be sealed, and a penalty provided for a broken seal which cannot be satisfactorily explained. Such sealing gives considerable protection, but is not positive guard against the unscrupulous taker, and it requires regular supervision on the part of the water department. The general extension of sealing throughout fire systems would be considered rather undesirable by the underwriters, from the tendency it has to take the responsibility for the private fire apparatus away from the mill people, thus encouraging them to rely more and more on the public department, where experience is believed to indicate that a good private fire brigade is always desirable in a large manufacturing property.

(*c*) A $\frac{5}{8}$-inch by-pass may be provided around the main gate where the fire service enters property having private protection. A water-works official can quickly slip a meter into this connection, shut the main gate without

notice, and thus instantly detect a flow of water. This method gives no constant watch, but, in some cases where conditions will permit, may give the water-works superintendent all the means he needs to feel reasonably sure as to the use of private fire pipes.

(*d*) Proportional meters consisting of a weighted check valve with a small meter in a by-pass around it can detect very small flows, and will give good results where the fire services are used for fire purposes only, and where any other use which the detector may indicate may be considered a violation of the contract, resulting in a penalty. This device, it is believed, has possibilities of further development into a more convenient and serviceable piece of apparatus.

(*e*) Various other special devices and inventions have been partially considered, but need more study before a report of value can be made.

Sixth. Data as to the layout, use, value, and cost of private fire protection were suggested by the questions submitted to the Committee. The following facts are presented: —

(*a*) Extensive private fire systems are laid out by the engineering departments of insurance associations.

(*b*) The simplest arrangement of piping is always desired.

(*c*) The general custom is to absolutely separate the fire pipes from those supplying water for manufacturing and similar purposes.

(*d*) Outside gates with indicator posts are provided on connections going inside of buildings, to permit shutting off water in case of breaks.

(*e*) The requirements of the water department as to the plans of private piping, uses of water, notice of tests, etc., should always be strictly followed by the protected risk.

(*f*) A yearly test of the capacity of public water, to ensure that all is in good condition, gates open wide, etc., is usually desired by the underwriters.

(*g*) Private protection usually costs the owners from three to five per cent. of the total value of the property which could be destroyed by fire. A $300 000 plant, therefore, requires from $9 000 to $15 000 for full equipment.

(*h*) From $100 000 000 to $200 000 000 is annually destroyed by fire in the United States, and private protection is the best means of reducing this loss.

(*i*) Records for the year 1900 from a group of protected risks manufacturing cotton and woolen goods, paper, and general metal work, with an aggregate value of $900 000 000, show that only 450 fires were reported with a total loss of $555 000. Three hundred and seventy-nine of these fires caused a loss less than $1 000 each; 59 less than $10 000, and 12 a loss of over $10 000. In the case of the 12, the large loss was due to some deficiency in protection or some accident.

We suggest that a committee be appointed to continue the subject and investigate means whereby assurance may be had that private fire pipes are used for fire purposes only, and report to the Association at some future meeting. We also suggest that such committee be requested to confer with the American Water Works Association, the National Fire Protection Association, and any other similar organization which may desire to coöperate on this subject, in order that the experience of all may be obtained and that any further action may be uniform and harmonious.

SEPTEMBER 11, 1902.

MR. WASHINGTON PAULISON.* I move, Mr. President, that Mr. Crandall's report be received and approved by the Convention.

MR. FRENCH. I think Mr. Chase ought to be heard from before we take any action.

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* Superintendent of Water Works, Passaic, N. J.

THE PRESIDENT. We should be glad to hear from Mr. Chase as a member of the Committee.

MR. JOHN C. CHASE.* Mr. President, I find myself in the rather unenviable position of not being able to agree upon all points with my esteemed associates on either side of the fence, but I do not know that my position is much worse than that in which a distinguished justice of the United States Supreme Court found himself in regard to the insular decisions, which some of you may have heard spoken about more or less last winter. On the fundamental proposition I do not differ materially from that held by the water-works members of the Committee, and I am not able to endorse all the views of the other members; but I have very briefly reduced to writing what I have to say, and it is as follows: —

Report of Mr. Chase.

It appears to be beyond question that there is a gross misuse of fire service systems, but it is only fair to assume that in many cases the unlawful use is due to a low standard of morality in regard to corporate rights in water rather than wilful larceny.

The municipality having assumed the responsibility of providing a water supply for fire protection, the expense of the same being uniformly distributed by taxation among those benefited, I hold that those who, at their own expense, equip their establishments with additional means for the more effective prevention or suppression of fires should not be subjected to any charge, except what may be required to cover the expense of the supervision needed to make certain that no unlawful use of the equipment is made. I do not consider that the benefit derived by the consumer in the way of decreased insurance premiums, or the indirect gain to the community by preventing a fire has anything to do with the question at issue. The generally understood custom credited to railroad corporations of "putting on all that the traffic will bear" should have no place in water department management.

I believe that all expense of connections and necessary indicating devices to insure that no improper use is made of the fire service pipes should be borne by the consumer, also any changes in the street mains made necessary by the requirements of the system to be installed. The unlawful use of the pipe system should be punished by a deprivation of its benefits.

THE PRESIDENT. Gentlemen, this report has come before the Association in a very interesting form, and it is now before you for your discussion and action. I trust it will receive careful consideration at your hands. We should be glad to hear from Mr. Paulison now.

MR. PAULISON. We have furnished water to manufacturers to be used only for the extinguishment of fires, and we have relied upon

* Civil Engineer, Derry, N. H.

them to use it for that purpose and that only; but we have found in many cases that they used it for other purposes. We have put on meters and we have found that they worked satisfactorily. Now, inasmuch as we charge the city for hydrants, I don't understand why we should allow manufacturers to have them for nothing. On the contrary, as they receive a benefit from them, and as the water company is in the market and doing business to make profit, I can't see why the manufacturers should not pay.

MR. ALLEN HAZEN.* Mr. President, it seems to me that the evil of stealing water from city pipes is a very serious one. I know about these matters only occasionally and incidentally, but the frequency with which I have come across cases where manufacturers were drawing large quantities of water from pipes put in for fire purposes only indicates to me that it is a pretty prevalent vice, and I think that something ought to be done to check it. Just the best way of getting at it, I don't know. Mr. French's suggestion rather appeals to me, and I should like to see all these reports accepted, and a committee from this Association, acting with committees from other associations, take the matter up and see what means can be devised for making sure that pipes for private fire purposes are not used for other purposes.

Just as illustration of what may happen, I was in a small city a few weeks ago with Mr. Connet, to see what we could find out as to where a very large quantity of water was going. A Venturi meter was put on the supply, — Mr. Connet operated it, — the reservoir was cut out, and we pumped directly into the mains. The city was divided up into sections, each supplied through one gate, and those I had closed in rotation while Mr. Connet noted the record of the Venturi meter. In that way we found where the bulk of the water was going, and then followed it up. We found, for instance, that one mill which had a 6-inch pipe connected with the sprinkler system, and supposed to be connected with nothing else, — the mill was not paying a cent for water, — was drawing as much water as it was possible to get through a 6-inch pipe under a pretty fair head, something like four or five hundred thousand gallons per day. There were a few other mills which were n't drawing so much, but the water which was taken in that way formed a very considerable percentage of the total amount of water which was being supplied in the town. Now, I don't know what the best way to get at this may be, but

*Civil Engineer, New York, N. Y.

it certainly is a very serious evil, and an evil large enough to require very radical means for its treatment.

Mr. W. C. Hawley.* I notice the extreme delicacy of the gentlemen of the Committee about using the plain Anglo-Saxon word "steal" in connection with this matter. I can't understand it, unless it be on the principle upon which a case, which I heard of at one time, was decided, where a private company arrested an individual for stealing water, — that was the charge. The justice of the peace before whom the case was tried discharged the man on the ground that "water is free," and therefore could not be stolen. [Laughter.] I do not see why when that which represents capital, money value, is appropriated by one to whom it does not belong it is not stealing, and I think we make a mistake when we attempt to cover it over by using a smooth, easy word. Every water-works official knows that water is stolen, and that many times it is stolen in large quantities. One of the largest water-works companies in this country was very nearly wrecked financially a few years ago by the deliberate stealing of water which went on for months. In spite of the vigilance of the superintendent of the company, and repeated efforts to locate the leak, which happened to be on a branch from the force main very near the pumping station, they were unable to find it until the company had been forced to make a large expenditure for an additional supply.

In regard to a method of furnishing a fire supply independent from the supply for manufacturing purposes, and doing it in such a way that the stealing of water can be detected, I found near Pittsburgh a very successful method in use, one which I believe is approved by the underwriters, and which is very satisfactory both to the manufacturing concern and to the water company. It was installed by my predecessor, Mr. W. A. Alexander, and was described by him at the Chicago meeting of the American Water Works Association last spring. A 12-inch main runs in, supplying water for manufacturing purposes. Parallel with that is another 12-inch main to supply the water for fire protection. A valve on this 12-inch fire line is operated by hydraulic pressure, — an hydraulic valve, — and is ordinarily closed. At one or more places through the plant there are connections from the ordinary service line to a pipe running to the cylinder on this hydraulic valve, and in case of a fire the turning of the cock opens that valve within a few seconds,

* Engineer and Superintendent Pennsylvania Water Co., Wilkinsburg, Pa.

and turns on the whole pressure for fire service. In order to detect the possible taking of water from this service, except for fire protection, a three-eighths inch meter has been connected to the fire line, discharging to a drain, so that whenever pressure is on this line the meter registers. The valve is tested at least once a week, and the tell-tale meter is read at the same time that the meter which is on the regular supply line is read, every day, so we can detect at once if any considerable quantity of water is taken from the fire line.

THE PRESIDENT. If Mr. Kimball, of Knoxville, Tenn., is in the room, we should be glad to hear from him.

MR. FRANK C. KIMBALL.* The report of the Committee deals with practically two distinct subjects: One, the apportionment of charges for private fire protection, and the other the means of controlling the supply. Now, as regards the apportionment of charges for fire protection, there is, of course, a varied opinion, and the Committee seems to be divided on that more than they are on the other.

In a municipally controlled plant, it may be a question whether any charge should be made or not. That should be governed more, perhaps, by the way in which they keep their accounts, — whether they charge for hydrant service and fire protection, or, as was very pertinently stated yesterday, whether it all was charged up to the consumer. In a privately owned plant, such as I represent, there seems to be no question but what some charge should be made; there may be a question as to what that charge should be.

In our plant we have a charge, but that charge is graded or arranged in such a way that if our customer for fire protection is also a customer to a certain amount for water for other purposes, we give him his fire protection free of charge. That, I think, covers the case as raised by Mr. French. In other words, we are in business, of course, for what there is in it, but at the same time we are ready to protect our own customers. Those who are not our customers to any further extent than for fire protection we expect to pay for it.

Regarding the means for controlling the supply to manufacturers, mills, and other establishments, I think there is no difference at all, as near as I can find out, among the members of the Committee, that some means should be taken to control the supply. All men who have had any experience with water works, I think, will agree with me in saying that sooner or later, in some place or other, they have

*Superintendent of Water Works, Knoxville, Tenn.

run across cases of stealing, if you choose to use the word; although I am firmly convinced from my experience that a large number of the cases of the surreptitious use of water are without the consent or the connivance of the owners of the property themselves. In the South especially, more than in the North, pipes are laid underground more because there are few basements even to mills or manufacturing buildings, and it is the easiest thing in the world for an engineer who wants a supply of water at some part of his plant to shut a gate controlling the main supply, — they all have to be gated, of course, to conform to the underwriters' requirements, — make a tap dry, and run his supply pipe wherever he chooses underground; and I have yet to discover any adequate means of inspection which will take care of a pipe of that kind.

We have had some difficulty in our place on just this point, and two or three years ago we adopted a method of handling fire supplies, which was against their wish somewhat, I will admit, but has met the approval of the underwriters in that section, — possibly because they found they could not get a fire protection supply without it. [Laughter.] It is something that to my mind seems to overcome the objections that have heretofore been raised against metering fire protection supplies. We have no fire protection service larger than a 6-inch, and those we treat in this manner: A main line of 6-inch pipe is run into the premises, with a gate and indicator post on it as required, and around this gate is a by-pass of the same size as the pipe, 6-inch, on which, protected on one side by a valve and on the other by a check valve, a 6-inch meter is placed. (See Fig. 1.) This gives the full capacity of the pipe, and it also gives an opportunity to open this 6-inch gate in the main line, which ordinarily is kept closed and sealed, so as to give an additional supply, or give the supply that the meter may not give in case of fire; and at the same time the meter is of such a size that at the breaking out of a fire it will give practically all the water that is needed, and nearly as much as the main pipe itself will furnish. We then have the regular supply for the mill taken off inside of this gate and meter, so that the water used ordinarily passes through and is registered by this meter. That keeps the meter working, and it does away with the objection which is frequently raised that a meter on a fire line, not having any work to do, sticks and can't be used when it is wanted. It is inspected regularly once a month by the water company. Another thing which helps is that, according to the regulations of our company, a man in

our employ answers every alarm of fire, and it is his especial duty to look out for all gates on the line, such as this and others, and to see that the supply is all right. Until some arrangement is devised such as Mr. French mentions, as of a weighted check-valve or some other contrivance whereby the gate, which, for the protection of the company must ordinarily be kept closed, can be opened automatically, it seems to me as though this system which we have is about as good as anything.

In reply to a criticism which is made that a 6-inch meter will not register a small enough stream to account for all water that is used

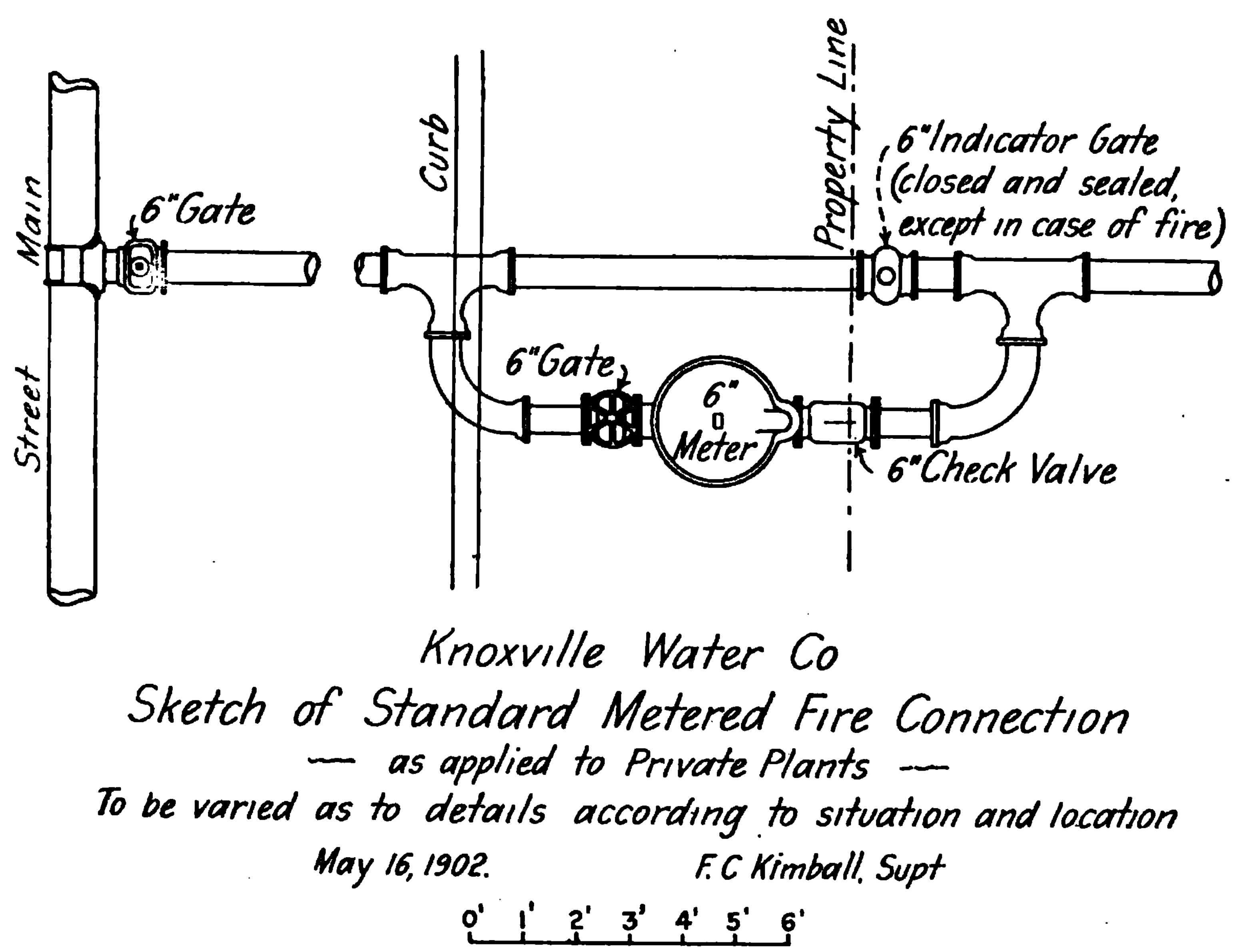

FIG. 1.

for ordinary purposes, I will state that the meters we use when tested before they have been placed have registered over ninety per cent. of an eighth of an inch stream, and over ninety-eight per cent. of a quarter of an inch stream, under thirty-five to forty pounds pressure, and if a manufacturer is using sufficient water to get fire protection free of charge the flow is sufficient so that there is practically, as meters go, no loss by lack of registration.

This plan that we have, I think, is at the present time the best that I have ever seen. It answers the purpose; it gives good protec-

tion; it is almost automatic, and it does away with just that thing that we are all troubled with, — the stealing or surreptitious use of water. That is one of the greatest evils, I think, that we have to contend with to-day.

I will say further, for it may be of interest to some members of the Association, that one manufacturer in our town rather objected to the arrangement, and was backed up by the underwriters who refused to accept the meter that we proposed to put on the pipe, although we were ready to demonstrate to him that under the system as we installed it we could furnish through that meter something over one thousand gallons of water a minute. He has taken the case into the courts, and I presume that if we live long enough we can get a judicial determination of whether that system is a proper one or not.

MR. KENNETH ALLEN.* I should like to ask the speaker what the general type of meter is that he uses on that service, whether a rotary or disc.

MR. KIMBALL. It is a positive registering meter. I would have no objection to giving the name of it, but I don't think it is exactly my business to advertise it. It is a positive acting rotary meter. And I will say further that the tests we have made of it show it is capable of delivering considerably more water than the manufacturer's limitation of it.

THE PRESIDENT. Mr. Hammond, who started the ball rolling on this subject and has taken a great deal of interest in it, I am sure can say something to us at this time which will be of benefit to us, and I will ask him to address us.

MR. J. C. HAMMOND, JR.† Mr. President, I hoped to be able to keep still to-day, and I guess should have if you had let me alone. Mr. Crandall is our chairman, and I would most certainly like to hear from him, and then I may have something to say later. I am sorry our Committee could not agree entirely, although we did agree on one thing; that is, we all endorsed the commandment, "Thou shalt not steal." Now, when a man comes to us and wants us to lay a main pipe through a street where he has some building lots to sell, what do we say to him? We say, "We can't lay that pipe until you guarantee us a fair return." A man has a pipe put into his house and then goes off to the seashore for two months, and during that time does n't use any of our water, but still he has to pay for

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* Engineer and Superintendent of Water Works, Atlantic City, N. J.
† Treasurer Water Co., Rockville, Conn.

it just the same. Some of us are staying at this hotel at four dollars a day, and suppose we happened to be invited out by some meter man to dinner, and we did n't want to pay for our dinner here because we had had it somewhere else. The hotel people would say to us, "Why, we had dinner ready for you here, and if you did n't eat it, it was n't our fault; you must settle just the same." Now, that is all there is about it. We have put our money into water works and we have water for sale, and a man can use it if he wants to. The manufacturer has this advantage, that if he uses a large quantity of water he gets a lower rate for it than a man who only uses a little. We put in a pipe for him for fire protection, which enables him to make a large saving in his insurance, and then he does n't want to pay us anything. They say that water is free and that air is free, but that is n't always so. You go down into the basement of this hotel and you will see some blowers, which make the air here very nice for us to breathe, and we say that air is free. But who furnishes the power and pays for running those blowers? [Laughter and applause.]

Mr. Kimball. If I may be permitted to say another word or two, in our town we have a condition of things which perhaps does not prevail everywhere. Our water is filtered, and there is absolutely no sediment in it as it is delivered to the consumer; consequently the danger of a meter clogging and thus being out of use at just the time when it is wanted does not exist, as it might in some other places where the water as delivered in its natural state contains more or less sediment and, as some of us have known, eels at times. Now it seems to me that the suggestion which was made to refer this whole question to a committee of the Association to act, if it can be done, in conjunction with a committee of the American Association and of the boards of underwriters, to formulate, perhaps not one but two or three or four plans or sets of suggestions whereby this matter may be handled without friction between the water companies and the insurance companies, is an excellent one.

The American Association at its meeting last June, after a report by a committee, passed a series of votes which, if followed out, would compel the placing of meters on all fire protection lines. While I firmly believe that that is a solution of the problem, still there are objections, as I know from personal experience, on the part of the underwriters against such a plan. I think, however, that a plan can be evolved, if all parties will go at the matter in the right

manner and in the proper spirit, which will be acceptable to all and will really be of advantage to the manufacturer. I have yet to find a manufacturer who is not willing to conform to the water company's rules if they are backed up by the underwriters' rules, or to the underwriters' rules if they are backed up by the water company. But as it is now he is between two fires, and he is going to protect himself if he can. If the various interests — the water companies, the public water departments, and the underwriters — can get together and formulate rules under which they will work in harmony and unison, I think this whole question will be settled, but I don't believe it will be settled until they do.

The President. We should be glad to hear from Mr. Crandall.

Mr. Crandall. I do not know, Mr. President, that I can add anything to what has been said on this subject. As far as I am personally concerned, my difference with the underwriters and with the insurance people is solely confined to the two points that were mentioned. I believe that the class of people who are wealthy enough to have private fire protection are not for that reason, simply because they are wealthy, entitled to get this better protection at the same price that a poorer protection is afforded to the average taxpayer. I also believe, and my experience has been such as to make it very apparent to me, that injury to others is liable to result from the presence of unnecessarily large services for fire protection, or too large services for any purpose. I do not want any larger service put into my house than is necessary to supply my needs, for an accident to it might cost me money. And when it comes to putting in such services as are now demanded for private fire protection and for elevators and for some other purposes, there is, I think any one but an insurance man would admit, danger to other interests — and I do not mean any disrespect to the insurance men. [Laughter.]

It may, perhaps, be interesting to members of the Association to know that in Burlington for a number of years past the fire protection of the entire city has been dependent upon the automatic action of a device for passing water around our high-service motor, about which you have all heard. This device acts from once a month to forty times a day, as the requirements may demand, and we have yet to experience any trouble on account of its failure to operate. Before the present device was in use, before our needs became such as they now are for large quantities of water in a short space of time, we had a similar arrangement of a check valve instead of a

butterfly valve, as we now use. That arrangement has been in use for twenty-two years, and the supply was never impaired on account of the failure of this automatic opening.

Reference has been made to the report of a committee of the American Water Works Association at the last meeting of that association, and perhaps it would be of interest to you to hear the report of that committee. I have the report here, and, if the President wishes, will read it.

THE PRESIDENT. I think it would be interesting to the members present to hear that report.

MR. CRANDALL (reading).

[*Report of Committee on Regulation and Control of Private Fire Service.*]

AUDITORIUM HOTEL, CHICAGO, June 13, 1902.

TO THE OFFICERS AND MEMBERS OF THE AMERICAN WATER WORKS ASSOCIATION:

Gentlemen, — Your Special Committee appointed to consider and report upon the question of the control and regulation of private fire service beg leave to report and recommend: —

That it be the sense of this Association, that the following regulations should be enforced: —

First. That all applications for attachments to street mains, for private fire service, be accompanied by a draft or plan of the proposed pipe system intended to be used on the property to be protected, together with a concise statement as to what other purpose the system might be used for.

Second. That upon approval of the application by the proper authority, its construction shall be such as to insure an accounting of all water used. Meters for this purpose to be installed and used.

Third. That by reason of the additional protection received by the property owner and because of the risk entailed upon other portions of the supply lines in case of a fire, it is eminently fair and just that there be made an equitable charge for every private fire service.

Fourth. That the objection of fire insurance companies to the use of water meters on private fire service attachments is not well founded, and should be opposed by the managers of water-works systems.

Fifth. That all expenses incidental to the installation of private fire service attachments, including cost of meters, be borne by the applicant or owner of the property.

Sixth. That the size of the openings for attachments shall be such as the engineer or superintendent shall find adequate, keeping in view, when deciding the question, the requirements necessary to properly protect other property on the same supply lines.

That to avoid surreptitious use of the water, devices be adopted by the superintendent and engineer to detect same, and in this connection we call attention to that of Mr. Alexander, of Wilkinsburg, Pa., as an example, and of which we will present a plan to the Association.

GEO. H. FELIX, *Chairman*,
C. E. BOLLING,
C. H. CAMPBELL,
Committee.

The device of Mr. Alexander is the one which Mr. Hawley described a little while ago.

MR. CHARLES K. WALKER.* Could I have a chance to say one word?

THE PRESIDENT. I was going to say that this discussion would not be complete unless we heard from Mr. Walker. [Applause.]

MR. WALKER. When gentlemen speak about another committee, I want them to understand that your present Committee has done the very best it could. I don't think anybody could possibly have done more than Mr. Crandall has done, and I am sorry he had to do so much and that I could n't have done more, but I am an old man, and I did n't want to get into this any more than I could help. Now, I don't ever want to be put on another committee with these insurance fellows, for if there is anything in the world they can do it is to make long statements. Why, they can typewrite the whole Bible [laughter], and they will want you to read it; but they don't say anything about who shall pay for the supply which goes into one of their mills. [Laughter.] They leave that out entirely. They say they don't want to pay for it, and they make great objections to meters. I put in a meter one day and I thought I had it fixed all right, and then they came along and said the gate must be opened and the meter taken out, and finally I had to fix it so the mill man could get his insurance, and in the meantime the fire pipe was tapped; but I don't suppose the insurance people cared much about that.

I don't see that there is anything unfair about this proposition that Mr. Crandall, Mr. Hammond, and myself have made, that the manufacturers should pay for the privilege of having the water furnished to their buildings, because we have to keep the reservoirs in repair, and we have to keep the pumps in repair, and we have to do everything in order that they may have their pipes supplied with water. We certainly ought to have some compensation for it. I don't say it should be very much, but there ought to be some. You can tell a man he will have to pay $40 or $50 or $100, whatever you think he ought to pay. I should say he ought to pay more for a 6-inch pipe than he would for a 4-inch; and I am satisfied that a 2-inch pipe in most cases will do. If you have 80 pounds pressure and a 2-inch pipe through the mill, it will wet down considerably; I know it would in my house anyway. They refuse to pay one single cent, but I think

*Superintendent of Water Works, Manchester, N. H.

it is no more than fair that they or the insurance folks or somebody should pay for it. Mr. Cook used to be a water-works man, and in those days he stuck to the ship. [Laughter.] Now he has become an insurance man, and I don't take any stock in what he says. [Laughter.] He can get up and address this meeting a good deal better than I can, but I don't take any stock in him now, because he is an insurance man. He gets more pay, — all these insurance folks get more pay than we water-works men, — and so I don't blame Cook. [Laughter.] All I have to say is that I think it is fair that we should have some compensation for the water we furnish to the mills.

THE PRESIDENT. Notwithstanding what Mr. Walker has said with regard to insurance men, I am very sure we shall all be glad to hear from Mr. Cook.

MR. BYRON I. COOK.* Mr. President, I am very sorry that I have lost the support of so able a man as my friend from Manchester, for I hoped he would still stand by me as he has many times in the past. But I think the olive branch of peace has been brought up from the South, and Mr. Kimball's idea is a good one. It seems to me that we are really very near together. What is wanted is a device of some sort to be placed on the fire supply that will be accepted by both parties. There is no doubt that some such thing is needed.

Now, so far as the matter of charging for fire protection is concerned, it seems to me that every city and town has a duty to protect its manufacturing industries. The factories in a town are what support the town and give it its income, and when competition is as brisk as it is to-day no town can afford to lose its factories by fire and run the risk of their rebuilding elsewhere. I think the suggestion that a committee be appointed from this Association to confer with committees from the National Board of Underwriters and from the American Water Works Association, with a view to devising some plan by which the water interests and the insurance interests can be protected, is a good one.

MR. R. C. P. COGGESHALL.† There is one thing I have noticed about these fire supplies. Even assuming that the fire service uses no water, yet if a superintendent will take the trouble to put a meter on the by-pass around the main gate in one of these large factories,

* Inspector Associated Factory Mutual Insurance Co.'s, Boston, Mass.
† Superintendent of Water Works, New Bedford, Mass.

when they are not drawing a drop of water, he will be surprised to see how much water is going away in leakage underground in almost every case. I venture to say he will find from six gallons a minute upwards going, and it is almost impossible to trace it because it is going in such minute quantities. Now, should n't there be something paid for that amount of water, which is going all the time?

THE PRESIDENT. We should be glad to hear from Mr. Fiske, who is a member of this Committee.

MR. HENRY A. FISKE.* Mr. President, I do not feel like saying very much on this question. I was the last member appointed on the Committee, one of the younger men, and I simply tried to do my part in the committee work. Perhaps I have spoken a little freely in the Committee, but if I have it was because I felt strongly.

The one thing I am most sorry for is that the Committee could not have brought in some sort of a unanimous report, not so much on account of the good that that report might have done, but because it might have avoided giving the impression to some people that there is any antagonism between the water-works interests and the insurance interests. As matter of fact there is none and should be none. There is no reason for any antagonism, not the slightest; and the only reason that there was any difference of opinion in the Committee was because the members took different views as to the equity of the case on just one point. On the main features of the case under consideration, and those which I think will be by far the most important in the future, we were entirely agreed. One great feature, it seems to me, of the work — and when I took it up I, perhaps wrongly, imagined that that was about the only feature this Committee was to take up — was that relating to properly guarding against the misuse of water. I knew that Mr. French had worked on the subject of the by-pass and other devices, our National Fire Protection Association had discussed similar devices, having had this thing up for a good many years, as to what to do to make sure that water was used for fire protection purposes only. The insurance people are with the water-works people heart and soul on that. There is no difference of opinion about it. We do not want the water used for anything but fire purposes. We believe it is an absolute detriment to the service to use the water for anything except the extinguishment of fire, and we impress that upon the assured: and if we find the assured using the water for any other

*Secretary, Underwriters Bureau, Boston.

purposes, we use our best endeavors to get him to stop doing it, and generally give him a positive command that it must not be done. And I know that it is a fact that the insurance interests throughout the country are working along in that same direction.

So, when you come right down to it, really the one subject which it seems to me this Committee had before it, or which any similar committee will have, is the question of devices for determining whether water is used for other than fire purposes. That is a very important question and one which will, I think, demand a great deal of work; and I am sure that the insurance people are ready to put their time and energies into this, in connection with the water-works people, in order to come to some conclusion which will be of advantage to all concerned.

MR. FRENCH. Mr. President, if I may be allowed one word, I would like to heartily endorse all that Mr. Fiske has said. In business we are competitors, but when it comes to the matter of fire protection our interests are identical, because protection is something which is equally desirable irrespective of where the insurance is, whether the property is a "stock" risk or a "mutual" risk. One or two points have occurred to me as possibly helpful to this discussion, and I will try to state them briefly.

First, once for all, let me explain where we differ in *principle*. Mr. Crandall's position is that protected mills get considerable advantage in insurance rates, — and they certainly do, — and that they ought to pay something to the public for this advantage. But our feeling is this: A man pays taxes; you all pay taxes. Now, if your house takes fire the public department comes and uses the public water freely, without any charge to you, and puts the fire out if it can. You have that service because you pay taxes. The proprietor of a large dry goods store down town, whose store has no private protection whatever, is entitled to the same service, and it is not an uncommon occurrence for the public fire department to pour water on such a store all night, perhaps until there is nothing but the cellar left, and no one questions the owner's right to this service. Now, we have felt that a mill owner has a right to say to himself: "If I put in automatic sprinklers, the chance of a fire getting under way is much lessened, and consequently the chance of my plant being destroyed is greatly reduced. I am entitled to fire protection because I pay taxes, and all I ask is that I be allowed to have that protection through the sprinklers which I will buy with my own money." These

sprinklers are better tools for using the public water than the public can furnish to the community at large. The only way to get these better tools is for the individual to purchase them; and the owner of the protected risk merely asks that the water that is standing in the mains in the street, ready to be played on to his property if it takes fire, be allowed to stand on his sprinklers, because he believes that the water will do more good, it will be more effective on his sprinklers. Really, it seems to us that the man is helping the community to bear the general responsibility of extinguishing fires and lessening the chance of a great fire. Now, because we felt that having paid taxes he had paid for that protection once, we thought it was not fair to make him pay for it again; and although what Mr. Crandall wants to charge is possibly no more than the man will have to pay to reimburse the water department for reading the detecting device, when we finally have a perfect one, nevertheless we felt that there was a fundamental principle, a question of right, which ought not to be covered up by a compromise, and that is why we took the position which we did.

I want very much to emphasize what Mr. Fiske says, that there should not be any antagonism between the insurance interests and the water-works interests, and we want to work harmoniously and strive for the same end. We are absolutely opposed to the stealing of water, and it ought to be stopped in every place where it is discovered. We feel that perhaps, after we have settled the principle of the thing in our minds, the chief work for us will be to find some sort of a detective meter, to devise some arrangement which cannot be objectionable to anybody, something that will not in any way decrease the efficiency of fire protection, and something that will give absolute security against all improper uses of water through the fire service. We have put a good deal of time into the consideration of that matter and made a good many experiments, and we think that something will eventually be developed.

Now, one other point is this: Mr. Walker has raised the question of the amount of water needed, and I just want to say that all our experience goes to show that now and then there comes a fire which will open fifty or one hundred automatic sprinklers. That happens sometimes owing to the fact that the fire burns in a place which the water cannot reach. For instance, in the mule room of a cotton mill it is not uncommon to have a fire in the mule-carriage. We had one the other day which opened two hundred sprinklers; if the water

supply had been better it would not have done it. But the fire sometimes burns in such concealed places, necessarily concealed in this case, because you cannot put sprinklers in a moving carriage; and the heat spreads through the room until the number of sprinklers which open is sufficient to pour out water fast enough to cool that heat as fast as it is made, and then no more sprinklers open. Now, if you limit your water supply to a very small pipe, the heat may go the whole length of the room and open every sprinkler, and when the large pipe is turned on, as Mr. Walker suggests, there will be a very heavy water damage; while if you have ample water to supply all the sprinklers which open at the very start, that water will catch the fire in its infancy and hold it, and you can perhaps shut the water off in a few minutes with a comparatively small loss. You take away from the great good of your sprinkler equipment the instant you throttle your water supply, for often you don't want many gallons in the total, but you may want a good many gallons in the first five minutes. That is a very important feature in fire protection.

Just one word more. As to this arrangement of Mr. Alexander's, I am afraid it would not be wholly safe in its present shape, because our experience with automatic dry pipe valves and various other automatic devices is that they are very likely sometimes to fail; and further with automatic sprinklers, if you had to wait until somebody pressed the button and opened the hydraulic valve, you would probably hamper your sprinklers at the start, when they need water the most. But somewhere among these various devices there will be something found which will give us a chance to stop all the improper use of water, which is very rightly named stealing, and when we get to that point I think that this question will very largely disappear, and that all water departments will be very glad to do all they can towards putting out fires, providing they can be sure that their fire services will not be abused.

THE PRESIDENT. I will ask Mr. Chase if he desires to say anything upon the report which he has made.

MR. CHASE. Well, Mr. President, practically everything which has been said to-day has been a rehash of what we have heard at previous meetings, comparatively few new ideas having been advanced; and while I might assume that there is justice in my cause, yet I believe justice should be tempered with mercy, especially about dinner time, and as it is now half-past twelve, I do not think I will inflict any remarks upon you.

On motion of Mr. R. J. Thomas, the convention adjourned to 2 P.M.

Upon reassembling, Mr. Fred Brooks moved that the three reports presented by members of the Committee on Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto be received and printed. The motion was adopted.

MR. CRANDALL. I was not here when the convention was called to order this afternoon, and I do not know what action was taken in regard to the reports of the Committee on Private Fire Protection. I would like to know what action, if any, was taken on that matter.

THE PRESIDENT. The reports of the Committee were received and ordered to be printed. That was the motion which was made and passed by the Association.

MR. CRANDALL. If there has been no motion made to carry out the suggestion in regard to appointing a committee to confer with committees from other associations who may be sufficiently interested in the matter to appoint such committees to consider the question of the control of such private fire services — I understand there has been no such motion made?

THE PRESIDENT. No such motion has yet been made.

MR. CRANDALL. Then I would move that the Chair appoint a committee of three water-works men, members of the New England Water Works Association, residing within fifty miles of each other and within one hundred miles of Boston, to take up this matter with committees which may be appointed with other associations.

Adopted.

MR. CRANDALL. Has there been no expression of opinion by the Association with regard to the different reports which were presented? There was a motion made this morning in regard to the adoption of one of the reports; was that acted upon?

THE PRESIDENT. All the business which was done, Mr. Crandall, was the passage of the motion to receive and print the report.

MR. CRANDALL. As a member of the Committee, I do not feel like making any motion in that regard, but it seems to me that an expression from the Association at this time would be very opportune.

MR. PAULISON. I move that Mr. Crandall's report be accepted and adopted.

A MEMBER. It seems to me that as we are about to appoint a

committee to confer with committees from other associations with regard to this matter, it might be somewhat premature for us at present to endorse any one of these reports. Perhaps it would be better to let the matter lie, to give the members an opportunity to think the matter over when they can have the reports in print, and at some future meeting they can endorse whichever report they choose.

MR. KIMBALL. While personally I am wholly in accord with the report presented by Mr. Crandall and his associates, I think myself that the better way to handle this matter now is to accept and print all of the reports, — there are some good things in all of them, there is no question about that, — and then give this new committee all the papers in the case, and let them, after consultation with committees of the American Water Works Association, of the Underwriters and other associations, if it is deemed best, bring in a report of what they think is advisable in the case.

I am sorry that Mr. Crandall in making his motion limited the choice of the President to certain districts, because that cuts out, perhaps, some members of former committees who have discussed this matter pretty thoroughly and are perhaps as competent as any one. If it is in order, I would move to amend the motion so that all limitations may be taken off the appointment of the committee, except, I believe, it should be composed of representative water-works men, and men, if you please, who represent both municipally and privately owned plants, as the underwriters, the insurance men, would naturally appoint a committee of their own to confer with our committee. If it is in order, or if it can be got at in any way, I think the limitation as to the location of the members of this committee should be removed. Will Mr. Crandall accept that as an amendment, if it is not too late?

MR. CRANDALL. I am willing to accept the amendment, providing you leave out the present superintendent of the water-works at Burlington, Vt. But the point I wish to get the sentiment of the Association on, and that I thought it would be advisable to have an expression of the Association upon, is that with regard to which the American Association has expressed its opinion, that is, as to whether this Association believes in free water for private fire purposes, or whether they believe that private fire services are assessable; and, also, on the other point as to whether there should be a limit placed upon the size of the services attached to the public

mains, — not necessarily a limit to the size of private fire pipes, but a limit to the size of any kind of services through which water may be drawn from the supply suddenly. The new committee appointed will be as much at sea with regard to what the opinion of the Association is on these two matters as we were. There is no question what the opinion of the insurance men will be, or of a man who is in charge of a large manufacturing plant, and if there is any considerable sentiment among water-works men in the same line as that which exists with the insurance men and the owners of the protected risks, I think it would save the committee a good deal of work to know it beforehand.

Mr. C. W. Sherman. I do not pretend to be very much of an expert in parliamentary law, but it seems to me that the original motion having been adopted by vote of the Association, the only way to make the change suggested by Mr. Kimball will be by a reconsideration of the vote and taking the matter up entirely anew.

Mr. Crandall. I am willing there should be a reconsideration on the terms I have mentioned.

Mr. George F. Chace. This present assembly is a very small part of the New England Water Works Association, and it does not appear to me that we can vote very intelligently upon matters about which we have never heard and know nothing. For my own part I do not know what the details of these reports are, and I should be glad to see the reports printed. It seems to me we could express ourselves a great deal more intelligently if we knew the details and had time to adjust them. I move that the whole matter be laid upon the table.

Mr. Paulison. I think if Mr. Crandall's report were adopted it would be a great help to the future committee to know the wishes of the Association.

Mr. M. N. Baker. I would like to make this statement: It seems to me that, inasmuch as the attendance now is so very much smaller than it was this morning during the discussion, or in the early part of the afternoon when the other motion was put and adopted, and inasmuch as some of the members who are interested in the discussion have, I believe, left the city with the understanding that final action had been taken, there might be an element of unfairness in re-opening the subject until notice has been given that it is to be taken up again. I say this without any regard to the manner in which my sympathies run on this general subject.

MR. CRANDALL. Mr. President, I appreciate the fairness of what Mr. Baker has said, but I would still like to know what the sentiment of the people here present is, not as a statement of the opinion of this Association, but simply for the information of the Committee as to what the opinion of the people now present is on the subject.

MR. CHACE. Does n't the motion to lay on the table take precedence?

THE PRESIDENT. I believe it does.

MR. FRED BROOKS. It seems to me if the motion to lay on the table prevailed it would still be open to the gentlemen present, if they chose, to make some informal expression, which would not go on record at all, as to how many favor and how many do not, the point suggested.

The motion to lay on the table is carried.

MR. KIMBALL. Now, with Mr. Crandall's permission, so that we can strike out the limitation, I move to reconsider the vote adopting his motion, with a view to offering it in another form covering practically the same matter.

Adopted.

MR. KIMBALL. Now, I would move that a committee of three be appointed by the President, whose duty it shall be to ask for the appointment of and to confer with similar committees from the American Water Works and other kindred associations, and also with the various underwriters' associations, to agree, if possible, upon some adequate means of controlling private fire supplies acceptable to all parties concerned, including therein all questions relating to charges therefor and similar matters.

MR. HAMMOND. I understand the question of payment is eliminated now, that it is simply to devise some means of detecting the use of water and has nothing to do with the pay; am I right?

MR. KIMBALL. I think the question of control includes payment as well as other questions connected with it. The question of payment is one form of controlling in all these things.

MR. JOHN O. HALL. I was not present this morning at the discussion of this subject, but I trust that the committee will have ample authority to cover the whole ground, because I believe it is a vitally essential point in the matter of water-works operation and control. A remark was made yesterday in reference to a just return to the water department for all demands made upon it, and it seems to me

that here is a question that the communities are vitally interested in. The community should not be taxed, the individual taxpayers should not be compelled to bear any burden which by any interpretation can pass into an individual benefit to somebody else; and this whole matter, it seems to me, should be very carefully considered, and the committee appointed should have ample power to cover the whole ground and take in the whole bearing. This is an element of vital importance to water-works departments, which are servants of the communities, and they should be very careful to protect the communities which they serve.

MR. SHERMAN. I rise to a point of order, Mr. President. If I understand parliamentary law correctly, the motion to reconsider the vote on Mr. Crandall's motion having been carried, the question now comes on Mr. Crandall's original motion.

THE PRESIDENT. Do I understand that Mr. Crandall accepts the motion of Mr. Kimball as a substitute for the original motion?

MR. CRANDALL. Yes; with the understanding that the President in his appointment will except the superintendent of the Burlington works.

Mr. Kimball's motion was adopted unanimously, and the President announced that he would appoint the committee later.*

MR. R. J. THOMAS. Inasmuch as the committee's report is not adopted, would n't it be well to discharge the committee now that you are to appoint another one?

MR. HAMMOND. I think the committee should be discharged, and thoroughly discharged.

MR. THOMAS. I move that the committee be honorably discharged.

MR. KIMBALL. With the thanks of the Association for the work which they have unquestionably put into this matter.

MR. THOMAS. I do not accept the amendment, for I do not believe in thanking committees. I move that they be honorably discharged.

Adopted.

*Subsequently the President appointed Messrs. F. H. Crandall, R. J. Thomas, and Elbert Wheeler as members of this committee.

APPENDIX A.

Statement of Conditions and Conclusions submitted by Messrs. Crandall, Walker, and Hammond, to the Fire Pipe Committee.

Investigations and experiments made for our Committee develop the following conditions: —

Water-works systems, both public and private, as we have them, are generally constructed with at least a double purpose in view, — the furnishing of fire protection and of water supply, both of which, under some circumstances, may be regarded as public necessities. In most cases it is not until a combined necessity becomes apparent that water works are built. Whether the necessity rests principally on account of the fire protection or the water supply afforded by the works, it matters not, as the need of either is sufficient to warrant the claim.

It is often forcibly impressed upon those in immediate charge of a system that much necessary work might more easily be accomplished and large expenditures frequently avoided were it not for the temporary impairment of some one's fire protection.

In case of public ownership of the water plant, the practice of making, in one way or another, a contribution toward the expenses of the water department in recognition of public fire protection afforded, and that of furnishing private fire protection and permitting fire services to be used for other than fire purposes without the knowledge or permission of the department, and without remuneration, is quite common.

Public sentiment, or the sentiment of the law-making representatives of the people, is found frequently averse to the strict enforcement of ordinances generally enacted for the prevention of the misappropriation of water.

Under public ownership, private fire protection has been frequently furnished without charge, the understanding being that such services should not be used for other than fire purposes, that the cost to the water department would be inconsiderable, and that the value of the protection afforded was not so great as by its free concession to constitute an injustice to other taxpayers.

Furnishing fire protection in accordance with present ideas necessitates larger mains than formerly, and much larger mains than, but for rendering private fire systems efficient, would prove amply sufficient. In recent years a large part of the annual expenditure of many works has been solely on account of fire protection. Pipes are everywhere being replaced with larger sizes for no other reason than to maintain the efficiency of plants for private fire protection.

Wherever pipes supposed to be used for fire purposes only are in use, water in considerable quantity is taken from them occasionally, if not habitually, for other uses.

The general public have had no opportunity to become aware of the extent to which the confidence reposed in the users of private fire services has been misplaced, nor have they had occasion to become possessed of correct information as to the value of the service rendered in permitting the connection of private fire protective plants with the public mains.

Every year's additional experience is making more apparent the shortcomings of the schedule rate and the so-called free systems, both in that

they offer no incentive to individual economy and thrift, and in that they indirectly encourage wastefulness and a disregard of the rights of others.

With the increasing popularity of the meter system, and its accompanying idea that one should pay for water in proportion to its use, the idea that the expense of fire protection should also be borne by those benefited in proportion to benefit received has gained in popularity.

With the increase in the number of small takers, ordinarily paying the minimum meter rate, and occasionally paying a larger bill on account of waste, a strong sentiment in favor of requiring every taker to assume the responsibility of meeting the expense of his own waste is developing.

The inadequacy of any means, short of placing the cost of waste upon the parties permitting it, to prevent the useless and unnecessary waste of water, has been repeatedly demonstrated.

It has developed that, under either the schedule rate or the so-called free system, no reasonably adequate supply can long prove sufficient.

The amount of water legitimately used or wasted by private fire pipe systems is not inconsiderable. The cost to the water department of maintaining the efficiency of private fire systems is not a small item. The pecuniary benefit accruing to the possessors of such systems in saving of insurance premiums is real, tangible, and considerable.

There is no question as to the value of and benefit to be derived from properly installed systems for private fire protection; nor is there any question as to who is the directly benefited party. The general public, like the beggar at the rich man's table, gets some crumbs of benefit from private fire protection, but there the parallel ends. The public is asked to foot the entire bill. Though the town derives benefit from the presence and from the sprinkling of its manufacturing industries, they are neither built nor rebuilt nor sprinkled for the benefit of the town.

Reasonably trustworthy evidence in regard to the method of use of private fire pipes is to be had at small expense.

The matter of expense necessary to be incurred in securing reasonably trustworthy evidence in regard to the method of use of private fire pipes is of no consequence whatever, as, be the expense what it may, it will, in a very short time, be returned manyfold in the prevention of waste, if in no other way.

Losses of ten pounds or more in pressure are not infrequently traced to leaks from private fire services, which have, perhaps, been running for months, but which, inasmuch as they did not cost the mill people anything, they did not feel were of sufficient consequence to merit attention.

In furnishing fire protection in the manner which has become quite generally the custom, even with the utmost care and the best installation, a risk, not only of absorption to no purpose of pressure, perhaps sorely needed on the premises or elsewhere, but also risk of unremunerative use and waste is assumed. The risk of loss of pressure here referred to is that of the entire absorption to no purpose of the fire protective efficiency of a plant, as by the discharge from a line broken by falling walls or from sprinkler heads in an already doomed building or in a building where the fire has been extinguished.

Such utter destruction of the fire protective efficiency of the water plant was experienced at Manchester, N. H.; Jacksonville, Fla.; Columbus, Ind., and other places, on account of the presence of unreasonably large services.

Very few of our systems can suffer the breaking of a 6-inch service and yet furnish fire protection to the neighborhood, hence the unwisdom, if services of that size are to be permitted at all, of permitting them to be so located as by any possibility to become broken.

The gate, supposed to be so located as to be accessible under any probable combination of circumstances, is about as apt to get shut when it should be shut as the gate on a by-pass around a meter is to get opened when it should be opened.

An investment in private fire protective appliances, supplemented by many times the amount invested in a water-works system, secures a saving in insurance premiums due to the entire amount contributing to the protection of the plant, and ordinarily affords the owner a large return on the comparatively small amount invested in private appliances.

The owners of private fire protected plants would have it understood that a water company or department is not entitled to remuneration for private fire protection, but only for the cost of connecting to such fire protective systems and the cost of reasonable supervision of the use of water from them.

Complex systems of cast- and wrought-iron pipe under from forty to one hundred and twenty pounds pressure can be maintained with scarcely any leakage. Such services are, nevertheless, where the conditions are such that waste costs the taker nothing and repairs are expensive, frequently found wasting considerable quantities of water.

These conditions have been demonstrated with particular clearness and force where the use of water for some time, without the knowledge of the user, measured, has been transferred from the schedule or so-called free list to the metered class. Premises where the users of water pay for use and waste at meter rates in proportion to the amount supplied are being satisfactorily served with one fourth the amount which was consumed when the water department, and not the careless and extravagant consumers, suffered the loss incident to waste.

Nowhere have these conditions been more conspicuously demonstated than in instances of public use. The caretakers of public premises where constant leakage from closets and other fixtures, and from fountains during the night time and during rain storms, has been the custom, have, when the loss incident to permitting such conditions was placed upon them, found that just as satisfactory results could be achieved with from one fourth to one third the amount of water used under the plan in vogue when the loss due to waste did not come out of their appropriation, and the benefit resulting from the better example has been worth more than the saving in water.

Statistics of like and even more advantageous results, achieved by causing the waste from private fire pipes to fall upon those permitting it, are not wanting.

The mill mechanic is not, and is not generally considered, the responsible cause of certain peculiar practices in regard to the use of private fire pipes, which have in numerous places come to light.

The agent, owner, or managing stockholder, who smiles when his engineer explains to him the ease with which the fire service may be tapped, and the party who, under the mistaken impression that he thereby furthers his own pecuniary interest, fosters the impression that a charge for private fire protection is unjust, and suggests means for "getting even" with the water company, are, beside public opinion, the forces to be reckoned with in an attempt to improve present conditions.

We find no means of securing reasonably trustworthy information in regard to the use of services used for both fire and other purposes. In regard to the use of such services, it appears that the manufacturer who told one of your Committee that, in spite of the best efforts of the water department, he could obtain, without their knowledge, all the water he wished from his fire service, was possessed of information on the subject no less accurate than that born of experience.

It is not on account of the illegitimate use which is likely, sooner or later, to be made of private fire pipes that meters are used, and a charge is, in many places, made for private fire protection, but for the prevention of waste, and because the protection thus afforded is of value and not reasonably to be granted for nothing.

The city of Burlington, Vt., has for years been dependent for fire protection upon the automatic opening of a by-pass around the motor used to

supply the high service, and has yet to experience any difficulty on that account.

Metered by-passes around weighted check valves are, in different places, affording means of securing, at small expense, reasonably accurate information as to the amount of water used through certain classes of services.

Metered by-passes of a much smaller size than the fire services, around gates in which they are placed, are, in some places, systematically used to determine the amount of leakage from services so equipped. Either the proportional device upon which the Factory Mutual people are at work, or a device such as is in use at Wilkinsburg, Pa., will furnish accurate information as to whether a service is used or not. As to the amount of water taken from a service, neither is constructed to furnish accurate information. For use on street sprinkling standpipes, or elsewhere, where the stream drawn is always the full capacity, either device affords reasonably accurate information as to the amount of water passing through it.

So far as we are able to learn, the device in use in Wilkinsburg, Pa., and some other places, for securing information in regard to the use of private fire pipes, is efficient, and not liable to get out of order. It consists of a hydraulic valve, with a small drip opening the instant the valve leaves its seat. By means of a meter on a waste pipe from the drip, the length of time which the valve remains off its seat is ascertained. The valve may be opened by means of stops on small pipe lines conveying hydraulic pressure to its operating chamber, from as many points as may be desired.

Superintendent W. S. Hamilton, of Youngstown, Ohio, has applied for a patent on a device consisting of a small metered by-pass around a large meter and check valve, which, it is stated, will be accepted by fire insurance companies.

We have been able to agree with the members of our Committee representing the owners of private fire protected plants and the insurance people on the following propositions: —

First. That the owners of private fire protected plants would have it understood, as was formerly quite generally the case, that by means of their private fire protective appliances, put in at great expense to them, they merely utilize to greater advantage protection to which they are legally entitled, and are not the recipients of any special service or protection.

Second. That stealing water from fire services is not right, and should be stopped.

Third. That the obtaining of trustworthy evidence in regard to the use of private fire protective systems is a growing tendency, and is entirely reasonable.

Fourth. That under schedule rate, or so-called free service, the appeal to the pocketbook is in favor of increased waste rather than economy, repairs being expensive, and a continuance of waste costing the taker nothing.

Fifth. That the work of this Committee will be of more value if mainly directed to securing a remedy for the misuse of private fire connections, rather than to the preparation of elaborate records of past abuses.

Sixth. That on every fire service running into a building there should be a main gate, so located as to be accessible under any probable combination of circumstances.

Seventh. That a charge for a permit to connect, equal to the cost to the public or to the water company, as the case may be, of the connection, would be reasonable and proper.

Eighth. That an additional charge for each additional hundred feet of water used in excess of the amount allowed for the minimum rate would be fair and reasonable.

Ninth. That in a constantly increasing number of cases, where to secure fire protection and water supply for a reasonable sum it has become necessary to limit the consumption to legitimate uses only, no so-called free use

and no waste being permitted, metering of private fire services is certainly a growing tendency. We, however, do not expect the custom to become universal for many years, if ever, and we think that probably, in a number of cases, metering will not be necessary, such methods as are employed in New Bedford and Providence perhaps, under some circumstances, sufficiently safeguarding the interests of the public.

Tenth. That existing conditions undoubtedly create a tendency to use meters of the ordinary commercial types for fire services. Our feeling is, that though present types of meters are not entirely satisfactory for the work, on the one hand through their inability to measure small flows, and on the other because of their possible excessive obstruction in case of large demands, they will, unless something more satisfactory is devised, probably be placed on private fire services.

Eleventh. That as a general proposition, taxpayers, required to pay for all they use and waste, may reasonably demand that others do the same and that trustworthy evidence, such as an automatic machine only can furnish, in regard to the use of a service, be secured in regard to the use of every service attached to the public mains. We, at the same time, appreciate that probably, in many cases, the interests of the public may by other means be duly safeguarded.

Existing conditions are, we find, in various ways demonstrating the impropriety of furnishing private fire protection for nothing. From the conditions as we find them, we would draw the following conclusions: —

The conditions encountered in different places are so different as to render impossible any conclusions of general applicability in regard to the amount or method of making a fair and equitable assessment for private fire protection.

The understanding that a service, supposed to be used for fire purposes only, furnished as has been the custom, will be used for no other purpose; that the cost of maintenance of such services for such purposes only is insignificant, and that the value of the protection afforded is not so great as by its free concession to constitute an injustice to others, is, in every particular, a misunderstanding.

The improper use of services, relative to the use of which no means of securing reliable information is furnished, is a natural consequence of their existence, to which the small value frequently placed upon private fire protection largely contributes.

It is not unnatural that the appropriation of a commodity esteemed to be nearly, if not quite, valueless, should be regarded as a trivial matter. Wherever the misapprehension, quite common at present, as to the value and cost of fire protection is coupled with an apparent willingness of water rate payers to bear the burdens of others, the present rates or lack of rates for private fire protection and the present method of use of such services may reasonably be expected to continue.

It is not wholly the well-known tendency to generosity with other people's money, but largely a lack of correct information as to the value of the service rendered, which is responsible for the discrimination frequently existing in favor of the ownership of private fire protected plants.

The granting for nothing of so valuable a service to parties abundantly able to pay a reasonable price for it is not charity, and amounts to more than ordinary generosity. It amounts to an injustice to other rate payers, which, in view of the fact that in the establishment of rates for the service of a public monopoly, neither charity nor generosity but justice only ought of right to figure, is conspicuously ill met.

Where the furnishing of private fire protection results in either expense to the furnisher or in benefit to the recipients of the protection, there should, in justice to all concerned, be a proportionate assessment.

With an increase in either the value to the applicant of the protection afforded, the cost to the water department of affording the protection, or

the risk to other interests entailed by the attachment desired, the rate for private fire protection should increase.

All known safeguards having been provided to lessen the risk to other interests, incident to the attachment of a large service to the system, the only way of meeting the unavoidably remaining risk is by its assumption by some one.

Though there are occasional instances of the assumption of a risk by one party for another without remuneration, the practice is not general, and we see no reason for its adoption by water departments.

By causing the rate charged for private fire protection to increase as the risk to other interests entailed by the service is increased, the creation of needless hazard incident to unnecessarily large services will be discouraged.

Large services, for whatever purpose, carry with them an element of danger to the neighborhood, and care should be taken not that fire pressure may not be accidentally destroyed, but that it must not be accidentally destroyed.

The misapprehension, which has become quite common in regard to the value of fire protection, results, it seems to us, largely from the practice of thinking and speaking of furnishing water for fire protection, instead of speaking and thinking of furnishing fire protection.

The extra cost of furnishing facilities for securing water in volume sufficient for fire protective efficiency is not conspicuously apparent to those not versed in such matters. To such a bill "for water furnished for fire protection," particularly if no water or very little water has been so used, is a stumbling-block.

Inasmuch as at current prices the cost of furnishing the water used for fire purposes forms so small a portion of the cost to the water department of furnishing the protection, a bill for "fire protection afforded," the form of expression in use in many places, is technically more correct, and perhaps affords less opportunity for misunderstanding.

That there should be misapprehension in some quarters in regard to the value of fire protection is not particularly strange. The minimum meter rate has often, at first, by some been regarded as an injustice. With better information on the subject, the legality and propriety of such a charge has come to be generally recognized, and meters for small consumers, expecting to pay the minimum rate, are in demand. With the increase of correct information on the subject of fire protection, a reasonable charge for fire protection, both public and private, will also be not only appreciated but demanded.

While differences of conditions to be met with in different places seem to render conclusions in regard to the amount and method of assessment for fire protection which shall be generally satisfactory out of the question, the relative value of services of different sizes is, under the various conditions encountered, approximately the same, and the charge for a 6-inch service may reasonably be made not less than from four to six times that of a 2-inch service under like conditions.

The water company or department placing at the disposal of a patron a plant the fire protective efficiency of which he could not duplicate for a hundred thousand dollars or more, and which it has, perhaps, cost several hundred thousand dollars to develop, is entitled to reasonable compensation for benefit in the form of fire protection, as well as in the form of water supply derived from attachment to the plant.

There is no doubt that in the past water companies have quite generally derived an unreasonably large proportion of their revenue from those to whom they have furnished water, to the great pecuniary advantage of those to whom they have furnished fire protection.

All that can be said in favor of the meter system in preference to the schedule rate system applies with equal or greater force in favor of secur-

ing reasonably trustworthy evidence in regard to the use of private fire pipes, in preference to furnishing such service without control or remuneration.

No municipal or private corporation can afford to imperil its plant and put its property where it can be used without its knowledge or consent, trusting to the user to make proper compensation.

A plumber could not be legally or reasonably compelled to permit A, B, C, and others to help themselves to his wares, trusting to them to make him a proper return. This very unusual method of doing business is no more legal or reasonable when applied to a water company, either public or private.

To the rule that everything may be carried to an extreme, the size of an automatic sprinkler supply is no exception. In this case we feel that the extreme is quickly reached. An automatic sprinkler may, by being at the right place at the right time, prevent a conflagration. Ordinarily the fire which opens more automatic sprinkler heads than a 4-inch service will supply has passed beyond the automatic sprinkler class, and brains are required for the direction of the deluge necessary to arrest its course. In any case, such a service should not be permitted without facilities for the prevention of its becoming a damage instead of a blessing.

The interest and other expenses of maintenance, a proper sinking fund contribution included, together make up the cost of supplying water and fire protection. To meet this expense, each party deriving benefit in any form from the maintenance of the plant should be assessed in proportion to the benefit he receives and his ability to pay.

Reasonably reduced rates to wholesale consumers of water are, provided for like quantities of water the rate is always the same, legal, and in such case do not create a material, if any, departure from assessment in proportion to benefit.

The claim that any sharer in the advantage, of whatever nature, conferred by a public water works should be exempt from making a proportionate contribution towards the general maintenance of the plant, interest included, is not well founded.

Referring to the four definite questions submitted to us, we find, —

In regard to the first, as stated a year ago, the opportunities for taking water, without the knowledge of the water department, afforded by the presence of private fire pipes, are frequently taken advantage of.

In regard to the second, the benefit to the general public from the presence of private fire pipes is not sufficient to warrant the assumption by the general public of the expense incident to furnishing them with water.

In regard to the third, the service rendered in supplying water for fire purposes only for private fire pipes, merits compensation.

In regard to the fourth, securing assurance of the use of private fire pipes for such purposes only is a matter of small expense, and may reasonably be required.

The cost of private fire protection may reasonably be estimated at a certain proportion of the total cost of fire protection; which latter often falls between one third and one half the total maintenance account, interest included.

The value of the protection afforded is many times its cost, and should be assessed upon those directly benefited. A percentage of the insurance premiums paid will, in many cases, furnish a satisfactory method.

In some cases it may be well to recognize the different fire protective efficiency due to different pressures. It is, of course, desirable that a rate be in proportion to the value of the service rendered. In case, however, of private fire protection, a very close approximation to such a rate it is next to impossible to determine without the coöperation of parties too deeply interested to admit of fair and unbiased action on their part. In public works, too, the charges are, and we think are liable for some time

to remain, so small a proportion of the value of the service that extreme accuracy in the detail of minimum assessment is uncalled for.

A minimum rate based upon the size of the service, in so far as the size influences the value to the user, the cost of maintenance and supervision, and the risk entailed upon other interests, somewhat in the following proportion, would be reasonable.

Taking a 6-inch service, without other information in regard to its use or other means of control than the assurance of the owner that it is used for no other than fire purposes, as a standard for comparison, minimum prices for fire protection in the following proportion would not be unreasonable.

	Size not limited. No definite control.	*Size limited. No definite control.*	*Size not limited but controlled.*	*Size limited and controlled.*
6-inch,	100%	75%	60%	40%
4-inch,	50%	35%	30%	20%
3-inch,	25%	20%	15%	15%
2-inch or less,	20%	15%	10%	10%

Larger services, proportionately larger prices.

Each of the above percentages has reference to the price established under the particular prevailing conditions for a 6-inch service understood to be used for fire purposes only, with no other information in regard to, or means of control of, its use than the assurance of its owner that it is used for such purposes only.

While a generally applicable rate or method of assessment is not to be expected, for minimum rates prices for less than which services of the sizes and under the conditions named will not be furnished, in the above proportion will ordinarily be found reasonable.

For water actually used to put out a fire, no additional charge over and above the minimum charge for fire protection, is contemplated.

We would direct attention to the recommendations of the American Water Works Association in regard to this matter, promulgated at their recent meeting in Chicago.*

This report, Mr. J. M. Diven, secretary of the American Water Works Association, informs us, was unanimously adopted by that association.

We heartily commend the action taken by the American Association, but would amend the first, fourth, and seventh paragraphs to read as follows:

First. That all applications for attachments to street mains for private fire service be accompanied by a draft or plan of the proposed pipe system intended to be used upon the property to be protected, together with an agreement that the service applied for shall be used for no other than fire purposes.

Fourth. That the attempt to secure large services for fire or other purposes, without furnishing reasonably trustworthy evidence in regard to the method of their use, is unreasonable, and should not be permitted by the purveyors of water and fire protection, whether acting for public or private corporations.

Seventh. That to avoid the surreptitious use of water, services unprovided with suitable devices for determining with reasonable accuracy the method of their use be not permitted.

A metered by-pass around a butterfly valve, arranged to automatically open and become locked open on a drop of pressure on its outlet side, or a metered by-pass around a weighted swing check, opening toward the private system in such manner as to throw its weight and become locked open upon a drop in pressure on its outlet side, or such unautomatic device as is in use at Wilkinsburg, Pa., may, without at all impairing the fire protective

* See page 303.

efficiency of the service, if permitted, furnish reasonably trustworthy information in regard to the use of a service used for fire purposes only.

The espionage necessary to insure the use of private fire services for no other than fire purposes is irksome to both the inspector and the inspected, and its long continuance is impracticable.

There are fewer places now than formerly where a small favored class get their water for about one fifth of the rate charged the general public, and a much better fire protection for the same rate as that charged the general public.

Though there is no more justice in the very small taker getting his service at less than cost and at the expense of the larger takers than there is for the large takers getting their supply at less than cost and at the expense of the smaller takers, the fact that the latter has frequently in former years been the case, both as regards fire protection and water supply, affords the reason for the present reaction in the former direction.

Where a charge for private fire protection is made, it is ordinarily less than one tenth the value of the protection afforded. In our opinion those who oppose so reasonable a charge for private fire protection are standing in their own light, for with schedule rates free lists are becoming out of date, and if "you can't fool all of the people all of the time," a charge seems to us inevitable. It is to be hoped that a happy and equitable mean may be reached.

We would recommend that, provided trustworthy evidence in regard to the use of the service and reasonable remuneration for the protection afforded be furnished, such applications for private fire services as will not unwarrantably jeopardize other interests be granted.

APPENDIX B.

Statement of Conditions and Conclusions submitted by Messrs. French, Fiske, and Cook, to the Fire Pipe Committee, giving more fully the reasons for the Conclusions in the Report which they submitted to the Association, and also somewhat extending the Data as to Cost, Value, etc., of Private Fire Protection.

In this statement, the questions given were those originally submitted to the Committee, and have been taken up in this case as they furnished convenient subdivisions of the whole problem.

First. "Whether the opportunities for the taking of water without the knowledge of the water department afforded by the presence of private fire pipes are frequently taken advantage of or no": —

We have found that the manufacturing plants having private fire protection supplied with water from the public mains may be divided into three general classes: First, there are those with unscrupulous management who deliberately, even to the extent of making secret connections, take the public water in quantities as desired, with the avowed intention of getting something which they need for nothing. We think this class is not very large, but they furnish the more glaring examples of the abuse of fire systems, and they contribute largely to the suspicion with which the fire service is often looked upon by the water-works superintendent. Second, we have a class which, we believe, includes the greater part of all the cases where private fire supplies are improperly used, where there is no actual intention to defraud the public, but where, through thoughtlessness or from a lack of reasonable appreciation of the rights in the case, water is taken now and then from the fire system for any pressing need. In general, in such cases the chief motive is to quickly get a supply of water when an *extra* amount is needed, or when the ordinary supply, such as the mill pumps, happens to fail. Convenience, therefore, is the guiding feature, and where the propriety of such takings is considered at all, the action is justified by the feeling that the water is so very cheap that to take some now and then cannot be wrong when it is for an emergency. The third class comprises the risks which have very scrupulous management, or which, from training, have learned that such takings of water are very much objected to by the water department, and always, when discovered, bring an earnest protest, so that, from years of such schooling it is generally understood by every one on the premises that water must not be taken from the fire mains except for fire purposes.

The first class may take much or little, depending on their needs and their daring. The second usually have to draw the water from some special connection made for the purpose, as by attaching a hose line to a nearby hydrant or sprinkler drain valve, or in some other way, making the taking more or less of a temporary affair which, in most cases, would naturally be discontinued as soon as the unusual demand were over or the normal supply restored. Such takers may use considerable water in one emergency if their needs happen to be great, but probably such users of water would not in a year take a *total* number of gallons which would be more than a small percentage of the consumption of the community at large. In the case of the first or the second class of concerns there may be some waste of water from the fire system, due to leakage, which, where the management was either unscrupulous or lax, might be allowed to go on for a considerable time without remedy.

Deliberate stealing of water should be punished the same as any other

stealing whenever detected. The thoughtless taking of water should be stopped whenever found, and the offending concern made to pay a good price for whatever they may have used, the amount being estimated as closely as possible under the conditions. It should be very clearly pointed out to such managers that the taking of water in this way is absolutely wrong, and that the large mill has no more right to use the public water without paying for it than has the smallest householder.

Outside of the question of right and wrong, even if large total amounts of water are not taken, it does often happen that occasional draughts of this kind are at such a high rate of flow as to make undesirable disturbances in pressure in the system, which may be mistaken for breaks, thus giving the superintendent a good deal of trouble and anxiety. Further, they all add an element of uncertainty always annoying, and especially so in those cases where a superintendent is earnestly endeavoring to account for practically all of the water pumped.

Second. "Whether the benefit to the general public from the presence of private fire pipes is sufficient to warrant the assumption by the general public of the expense incident to furnishing them with water, or no": —

We believe that private fire protection is in several ways a benefit to the general community. This being the case, we believe there is a sort of moral obligation, if not an actual legal one, to supply such systems from the public mains, and that, in most cases, it is the best of business policy on the part of the public to do this.

The expense to the general public would usually be nothing beyond the expense which would ordinarily be considered proper in providing water mains and hydrants in the streets surrounding the manufacturing property in question.

The above is based on the understanding that the cost of connecting the private system with the public mains will be borne by the protected plant; that some means entirely satisfactory to the water-works superintendent will be provided to insure that no water is used through the fire system for any purpose other than for fire, and that a yearly payment be made, sufficient to cover the cost to the water department of maintaining the necessary supervision. This supervision would probably come in some one of the ways to be suggested later, or in some better method which may eventually be developed.

Our reasons for believing that private fire systems are a benefit to the public are as follows: —

(*a*) A serious fire in a prosperous manufacturing concern is often a direct injury to a town or city, because such a fire, if only a partial destruction occurs, may throw a number of hands out of employment for several months, thus causing a direct loss to the community in wages earned. Again, if the fire is more serious and cripples the business entirely, the result may be, in these days of consolidation, the moving away of a valuable industry when a new plant is to be constructed somewhere. Further, a severe fire may easily spread and do damage to surrounding property.

(*b*) Good private protection, meaning complete sprinklers as well as pumps and yard hydrants, greatly reduces the chance of such a severe fire and renders the total destruction of the plant almost impossible.

This is because the sprinklers, covering every point, stand ready to put water on a fire night or day at the very instant that it starts. Further, conveniently located yard hydrants permit bringing powerful fire streams through short lines of hose quickly into use. The private system, therefore, uses the available water more surely and efficiently than is possible when depending upon street hydrants and a public department only, so that much less water is actually used than if there were no private system.

Therefore, we have considered that private protection is a benefit to the general public.

Our reasons for believing that there is a sort of moral obligation, and that it is good business policy to supply such private systems from the public mains, are as follows: —

(*a*) It has become the general custom for towns and cities to lay out their water systems with the idea of providing sufficient water for fighting fires, and then to provide public fire departments to use this water. The public, therefore, have, as it were, freely accepted the responsibility of extinguishing fires whenever they occur, using water and fire departments to their fullest extent for this purpose. It is also universally understood that any taxpayer is entitled to this protection.

(*b*) Private fire systems, as already fully explained, greatly reduce the chance of serious fires by providing extinguishing apparatus, which is even more efficient than that found in the best-equipped public fire departments.

(*c*) Such private protection costs from three to five per cent. of the destructible value of a manufacturing plant, and this expense is borne entirely by the owners of the protected property.

Therefore, owners of a manufacturing property who put in complete private protection are directly aiding the general public in meeting the common responsibility to guard against fire hazard. At their own expense they provide better tools for the public water to work with. For these reasons we have felt that it was good business policy to encourage owners to so protect their plants, and that it was only fair to permit the man who provides more efficient apparatus than that which the public can furnish to have ample water — always under proper regulations — to use through his apparatus when a fire comes.

Third. "Whether the service rendered in supplying water for fire purposes only to private fire pipes merits compensation or no": —

With all first cost of installation paid by the mill, and with a satisfactory guarantee in some way that water will be used through the fire service for fire purposes only, and with a well-laid-out system, having no greater chances for dangerous breaks than exist in any other part of the waterworks system, and with a yearly payment proportioned to perfectly reimburse the public departments for reasonable supervision over the fire service, we believe that no further compensation is warranted. The reasons for this conclusion are fully given in answer to the second question.

Fourth. "Whether securing assurance of the use of private fire pipes for such purposes only is merely a matter of a few dollars, and may reasonably be required or no": —

We believe that assurance can be secured as to the use of water through private fire supplies at moderate expense, though no one thoroughly satisfactory method, applicable to all cases, is yet available. We have considered the following plans, one plan being the best for one place, another for another, and so on, letting the special conditions existing be the determining factor in each case: —

(*a*) *Simple Lay-out and Inspection.*

With small manufacturing plants, having a simple fire system entirely separate from pipes carrying water for manufacturing uses, and laid out in a direct and straightforward manner, so that the water-works inspector can quickly become entirely familiar with every part of it, and with mill yards so open that water could not be used to any extent without attracting attention, we are inclined to think that no further protection other than periodical inspections and a clear understanding with the mill management would in most cases be necessary. Simplicity is best where it is good enough, so that in such cases we would rather advise against additional apparatus.

(*b*) *Small Detector Meter in By-pass around Main Gate.*

In some cases a ⅝-inch by-pass has been piped around the main gate at

the entrance to the mill yard and provided with connections for quickly connecting in a ⅝-inch meter. The water-works superintendent, or one of his assistants, would then once in a while slip a meter into this connection and close the main gate without giving any previous notice to the mill people. If the small meter began to move, it was an indication that water was being used, and investigation followed, and the trouble was at once sought out. This plan requires a little time now and then, but gives a superintendent easy means of watching his fire supplies, and, after a few cases of violation, results in making the mill people much more careful. The water should, of course, be kept shut off for only a few minutes, and a man should remain at the gate ready to open it instantly if a fire should occur.

Coming now to the cases where the water-works superintendent feels that some permanent and positive device is necessary on the fire service, the following plans have been considered: —

(c) *Ordinary Meters.*

Some one of the regular commercial meters would naturally first be thought of in such a case, but, practically, none of the ordinary types are really satisfactory for this work. Piston or disk meters considerably obstruct the flow, and if their moving parts become blocked may almost entirely cut off the water. The current type of meter introduces less obstruction but is not satisfactory to many water-works superintendents from its inability to detect the smallest flows. Again, the fish traps used with most meters are very likely to become seriously clogged by leaves, pipe scales, etc., which are apt to be brought along by the scouring action of the very heavy draughts caused by fire duty.

(d) *Sealing Hydrants and Valves.*

This plan has been quite successfully carried out in New Bedford, Providence, and some other places, and provides for sealing all hydrants and sprinkler drain valves. The seals are put on by the water department, to be broken only in case of fire, a fine being imposed for breaks at other times which cannot be satisfactorily explained. With a well-arranged public water department, this system will generally work satisfactorily. It does not, of course, detect concealed taps made by unscrupulous persons, but does provide against all ordinary takings.

From the underwriters' standpoint such sealing is not wholly desirable, and its general introduction throughout all private systems would be looked upon as unfortunate. This is from the fact that sealing tends to take the responsibility for the fire apparatus away from the mill force and leads them to rely more and more on the public fire department. Experience has shown the underwriters that good mill fire brigades are desirable even where there is an efficient public fire department, as the mill brigade, knowing the ins and outs of the mill buildings better, can often extinguish small fires with less loss on account of this knowledge, and further, every once in a while they are found absolutely necessary to guard the mill property when public departments are using their entire force and energies on a severe fire outside of the mill yard. Anything, therefore, which takes incentive from the mill brigade is somewhat undesirable.

(e) *Proportional Meters.*

In this type of measuring device a small meter — one-, two-, or three-inch — is put in a by-pass around an ordinary check valve, the clapper of which is perhaps weighted. Such devices, we believe, have promising possibilities. We have considerable data at our disposal on tests of meters of this kind. We have not as yet had time to develop what we believe is the ideal arrangement, but, even with present data, a metering device can be laid out which will detect very small flows, and which will give a fairly good measure of the water which passes through it. After some additional investigation we think it altogether probable that we could make definite

suggestions and furnish sketches for such meters, under different conditions, which would produce devices that would be satisfactory to the water-works superintendent and entirely unobjectionable to the insurance interests, and which would be serviceable in a great many cases where a permanent metering device or detecting device of some kind is desired.

There are several other devices of special design which have been suggested, but which as yet have not been fully investigated. It seems altogether probable that along some of these lines will be found a metering device which will be entirely satisfactory and in every way unobjectionable. Such a device would go a long way towards solving this problem, and it is earnestly hoped that further encouragement may be given to such investigation.

Fifth. "Any other facts in regard to private fire pipes, the manner of their use, the value and cost of the protection afforded, upon whom and how the cost of such protection should be assessed, etc., which the Committee may see fit to present": —

(*a*) *Manner of Use.*

All extensive private fire systems are laid out by the engineering departments of insurance associations in coöperation with the engineer of the mill. The underlying principle is to secure the simplest possible arrangement of the fire pipes. Outside gates with indicator posts are provided on all connections going outside of buildings. The aim is to locate these so that they will be surely accessible under any condition of fire, thus making it possible to cut off a broken connection and save the waste of water. The underwriters always require, where it is possible, the absolute separation of the pipes used for mill supply water from the fire systems. Protected mills are usually in a selected class and receive regular inspection, thus tending to keep the fire apparatus in reasonably good order. The underwriters always advise that the requirements of the public water departments be carefully ascertained and strictly lived up to, and that plans of the proposed private system be submitted to the water department whenever they desire them. In general the underwriters desire a yearly test of the yard system, putting on several lines of hose and running water for a few minutes, the idea being to represent actual fire conditions and ascertain that the whole system is in proper working order. This test often discloses partly closed gates, thus showing the value of periodic testing. The underwriters always advise making such tests strictly under whatever regulations may be made by the water department as to testing, and their inspectors are instructed to carefully follow all requirements thus laid down, giving notice to the water department in advance of testing wherever it is desired.

(*b*) *Cost of Protection.*

Modern protection means automatic sprinklers throughout practically all buildings, a good supply for these sprinklers from public mains or private elevated tanks of large size, and a secondary supply, generally from fire pumps. Pipes are then laid through the yards to supply the sprinkler connections and private hydrants. The cost of such equipment averages from three to five per cent. of the total value of the property which could be destroyed by fire. A modern manufacturing plant of moderate size is easily worth $300,000, so that the protection of such a property would ordinarily cost from $9,000 to $15,000. This cost is entirely borne by the owners of the manufacturing concern, and in addition to it there is, of course, a constant annual cost of moderate amount for keeping the system in first-class condition all the time.

(*c*) *The Value of Protection.*

The value of protection comes first from its efficiency in reducing the great annual fire waste of the country, and second from the freedom from

interruption of business which a bad fire always causes. The annual fire loss in the United States is from $100,000,000 to $200,000,000. This means so much actual value burned up, and this loss is paid for in the long run by the community at large. Each one of us contributes his small share. The insurance companies are the means by which this great loss is distributed over the whole community in a fairly uniform manner, so that no one of us feels his contribution very heavily, but we are none the less the losers and would be just this amount better off if the fire waste could be stopped.

The efficacy of protection in preventing these wastes is shown by the figures for the year 1900 for a group of protected risks. This group consisted of concerns manufacturing cotton and woolen goods, paper and general metal work, with an aggregate value of about $900,000,000. Four hundred and fifty fires were reported, with a total loss of only $550,000. Of the 450 fires, 379 occasioned the loss of less than $1,000 each; 59 less than $10,000 each, and only 12 caused a loss of over $10,000 each. In the case of the 12 fires where the loss was over $10,000, there was in every case some peculiar condition,—either deficiency in protection, or some accidental feature which allowed the fire to cause excessive damage.

When it is considered that many of these risks have inflammable stock like cotton, and that they all contain large amounts of fast-moving machinery, so that under ordinary conditions many fires and large losses would be expected, it is seen how very efficient good private protection can be, and how great its value is as a means of preventing our enormous annual fire wastes.

(*d*) *Upon Whom and How the Cost of Protection should be Assessed.*

We have already seen that the first cost of the private protected equipment is entirely borne by the owners of the protected plant, that the first cost and all cost of making connection to the public mains is borne by the owners of the protected plants, and that the owners should pay a yearly amount sufficient to completely reimburse the public water department for all reasonable cost in so supervising private fire service that they may ensure its use for fire fighting only. We believe that it is right and proper that all of these costs should be paid entirely by the private protected plant. This leaves no expense to the public department except the laying of water mains and the providing of hydrants in the streets around protected property, a work which they would ordinarily be expected to do entirely regardless of whether the manufacturing plant has private protection or not. Street mains sufficient for the reasonable protection of a property would ordinarily be sufficient to give ample supply to any private equipment, so that, in general, the private equipment makes no requirement on the public in addition to what the public would ordinarily be expected to do for any taxpaying property.

We believe the above covers all cases except the occasional one where a large manufacturing plant is located well beyond the limits of the public water supply, but still within the bounds of the town or city. In such cases we believe it reasonable, where conditions will allow, to extend the public water supply to the manufacturing plant, but to apply exactly the same rule as is applied to the extension of water mains into any district as yet thinly built up, namely, to assess a yearly charge on the manufacturing plant sufficient to pay a fair interest on the cost of the pipe extension, allowing this charge to be eventually eliminated if the natural building up in the vicinity brings an equivalent revenue from ordinary water takers. This is simply the application of an old-established rule, and we believe it is just as fair for the large manufacturing plant as it is for the one or two small householders who build beyond the limits of the water supply. Of course, if the manufacturing plant in question desired to use a considerable amount of public water at regular meter rates this, in itself, would often justify the extension outside of the fire protection question.

FINAL REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE.*

FREEMAN C. COFFIN, DEXTER BRACKETT, F. F. FORBES, COMMITTEE.

[*Presented September 10, 1902.*]

BOSTON, September 1, 1902.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — Nine months have passed since your Committee made its preliminary report and offered a draft of Standard Specifications for your consideration. The subject was discussed at two public meetings of the Association, and a number of written communications were read, all of which have been published in the JOURNAL. The Committee has since earnestly sought for other suggestions from those interested in the subject, particularly from experienced pipe inspectors, whose long practice at different foundries has given them an intimate acquaintance with the methods of making cast-iron pipe, and whose suggestions the Committee has found valuable.

The greatest cause of delay in the making of a final report has been the consideration of the subject with a committee which represents, to a large extent, the pipe foundries of the country. This committee began its consideration of the subject soon after the presentation of the report of your Committee on December 11, 1901. Their conclusions and propositions, which were issued in a printed pamphlet, and which are published as an appendix to this report, were not received by your Committee until June 4, 1902. This is not said in any spirit of complaint of the manufacturers' committee, but quite the contrary, as your Committee wishes to express its great satisfaction that the action of this Association in proposing Standard Specifications for cast-iron pipe should be considered a matter of such importance to the manufacturers of pipe that they were willing to spend the time and money necessary for so thorough a study of

* See Preliminary Report of the Committee, with Discussion, on page 85 of the JOURNAL (June, 1902).

the matter among themselves. This fact and the interest shown in our action by other associations of a like nature to our own, not only in this country but in England, that through their representatives have given the Committee their assurance of a willingness and desire to coöperate with us, has been of great encouragement to your Committee to persevere when at times its success in finally attaining a satisfactory result seemed uncertain.

After receiving the report of the committee of the pipe manufacturers and giving it careful consideration, a conference was arranged with a sub-committee consisting of Messrs. Walter Wood, L. R. Lemoine, A. H. McNeal, G. J. Long, A. C. Overholt. These gentlemen met your Committee in Boston, coming here twice for that purpose. Altogether we had four sessions of several hours each, spent in discussing all of the points relating to the manufacture of pipe and the bearing of the different clauses of the proposed specifications upon them.

In these conferences each committee naturally looked at the subject from its own point of view, on one side the manufacturers seeking to provide for the practice that would occasion the fewest difficulties in the foundries and secure a minimum of cost in the product, so far as consistent with good quality; on the other, your Committee seeking to secure the best possible pipe, made in a way to give the least trouble in its use, also at the lowest cost compatible with these requirements. The several points were very fully discussed, and it is the belief of your Committee that the net result was an endeavor to eliminate such requirements as would result in excessive cost of manufacture without a corresponding increase in quality of the pipe or facility in its use, and to retain all requirements tending to secure actual benefits to the users of pipe, your Committee believing that the consumers can well afford to pay any small difference in cost which may be necessary to secure such benefits.

While your Committee conceded some of the changes in the preliminary specifications asked for by the manufacturers, and met them part way on other points, there were still a few which it did not feel that it was wise to change and upon which it cannot be said that the conference came to an entire agreement. It is hoped, however, that these points of difference will not stand in the way of a cordial acceptance of the specifications by the manufacturers, and that they will be adopted as the basis of general practice in the manufacture

of stock pipe, as it was intimated that they would be, if an agreement was reached.

The provision of the specifications which caused the most debate was the one which was perhaps the most favorably commented upon by those of our members taking part in the discussion already published in the JOURNAL, namely, the proposition to make all pipe of the same nominal size, of a uniform outside diameter. It seemed to the Committee that this change would be acceptable to the manufacturers on account of the reduction in the number of patterns required. During the consideration of this subject in the conference referred to, it was made clear to your Committee that the saving in the patterns for the outside of the pipe was a small matter compared with the vastly increased number of fittings which would be required for the casting of the inside of the socket of the pipe where the inside diameter varies with each class. There was besides a danger that the pipes would be of poor quality if too great difference in the thickness of the pipe were made by increasing the thickness of the clay on the core.

It would require too much space to explain this matter in detail here, but your Committee became fully satisfied that, in order to secure uniformly good pipe without a large increase in cost, it would be necessary to modify the design of the pipe as given in tables Nos. 1 and 2 of the preliminary specifications. Wishing to retain the advantages of a single class of special castings for all of the classes of the smaller sizes of pipe, and the possibility of using the pipe interchangeably, it has revised tables Nos. 1 and 2 in such a manner that there are two patterns of outside diameter for all sizes of pipe from four inches to sixteen inches inclusive, with one class of special castings; three patterns for all sizes of pipe from eighteen inches to sixty inches inclusive, with two classes of special castings for sizes eighteen inches to twenty-four inches inclusive, one for the light and ordinary weights of pipe and another for the heavier weights, and three classes of special castings for the larger sizes.

The different classes for each pattern are obtained by making the outside diameter equal to the nominal diameter plus twice the thickness of the heaviest class of that pattern, and the pipe of the heaviest class have the inside diameter equal to the nominal diameter and a uniform thickness from end to end. The lighter classes are obtained by reducing the thickness of the shell on the inside, except at the extreme ends, where it is to be the same as in the heaviest

class and tapered to meet the thinner portion of the body of the pipe through a length of six inches.

It may be said that this design will result in a pipe line for the lighter classes which is not uniform in inside diameter from end to end. The Committee have considered this matter of the enlargement of the body of the pipe, and, in view of the many uncertain conditions which necessarily exist in all pipe lines, especially when they are not new, is of the opinion that the effect is inconsiderable and, whatever it may be, is on the side of increased capacity. In any event, this method of manufacture is the only practicable one, in the opinion of your Committee, by which pipes can be made which are interchangeable and which can be used satisfactorily with one pattern of special casting up to sixteen inches in diameter.

NOTE. — It may be said in reply to the last statement that some cities are having all of their pipes cast with uniform outside diameters. This is true, and attention is called to the fact that the range of weight or thickness used by any single city is much narrower than that provided for in the tables of these specifications, which are designed to meet the requirements of all users of water pipes, and necessarily cover what some consider very light pipe and what others consider very heavy. The Committee believes this range of design to be necessary, and wishes to emphasize its conviction that it is not the province of Standard Specifications to dictate engineering design.

To use one pattern of special castings with two patterns of pipe, the joint room for the larger pattern is made a little thinner than the standard joint of the pipes and a little thicker for the smaller pattern. No joint room, however, is less than .35 of an inch, and none exceeds .60 of an inch. As the special castings occur only occasionally in the line, the above variation in joint room cannot be a serious matter, particularly when we consider past experience in this respect.

All suggestions made in the discussion of the subject have been carefully considered by your Committee, and many of them incorporated in the final form of the specifications now presented. These may be readily found by comparison with the preliminary specifications, as well as the changes made at the request of the manufacturers' committee, and it seems unnecessary to occupy time and space to refer to them in detail.

So much time has been occupied in the consideration of the specifications that your Committee was not able to submit at the present

time tables showing the design and standard weights of the several classes and patterns of special castings.

In general design the special castings recommended are of the pattern now used on the Metropolitan Water Works. If these specifications are adopted by the Association, tables giving the dimensions and weight of every special casting required in ordinary practice will be prepared by your Committee, to be published with the specifications in their final form.

Respectfully submitted,

FREEMAN C. COFFIN,
DEXTER BRACKETT,
F. F. FORBES,
Committee on Standard Specifications for Cast-Iron Pipe.

NOTE.—Many of these tables have since been prepared and are now printed with the specifications. The remainder of the tables are expected to be ready for publication in the next issue of the JOURNAL. The specifications with the complete tables will then be reprinted, and will be for sale by the Secretary.

DECEMBER 1, 1902.

PROPOSED SPECIFICATIONS.

NEW ENGLAND WATER WORKS ASSOCIATION STANDARD SPECIFICATIONS FOR CAST-IRON PIPE.

Description of Pipes.

SECTION 1. The pipes shall be made with hub and spigot joints, and shall accurately conform to the dimensions given in tables Nos. 1 and 2. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least twelve feet in length, exclusive of socket. For pipes of each size from 4 inches to 16 inches in diameter there shall be two standards, and for each larger size three standards of outside diameter. The inside diameter of each class shall be increased from the nominal size in the manner hereinafter specified, so as to obtain the standard thickness and weight. For pipes from 4 inches to 16 inches in diameter one class of special castings shall be furnished with all classes of pipes. For pipes from 18 inches to 24 inches in diameter, Class D special castings shall be furnished with pipes of Classes A, B, C, and D, and Class F special castings with pipes of Classes E and F. For pipes 30 inches in diameter and larger, Class B special castings shall be used with pipes of Classes A and B, Class D special castings with pipes of Classes C and D, and Class F special castings with pipes of Classes E and F.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of six inches from each end of the pipe, so as to obtain the required standard thickness and weight for each size and class of pipe.

Allowable Variation in Diameter of Pipes and Sockets.

SECT. 2. Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular

gages, and no pipe will be received which is defective in joint-room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipes shall not vary from the standard dimensions by more than .06 of an inch for pipes 16 inches or less in diameter; .08 of an inch for 18-inch, 20-inch, and 24-inch pipes; .10 of an inch for 30-inch, 36-inch, and 42-inch pipes, and .12 of an inch for 48-inch, 54-inch, and 60-inch pipes.

Allowable Variation in Thickness.

SECT. 3. For pipes whose standard thickness is less than one inch, the thickness of metal in the body of the pipe shall not be more than .08 of an inch less than the standard thickness, and for pipes whose standard thickness is one inch or more, the variation shall not exceed .10 of an inch, except that for spaces not exceeding eight inches in length in any direction, variations from the standard thickness of .02 of an inch in excess of the allowances above given shall be permitted.

Defective Spigots may be Cut.

SECT. 4. Defective spigot ends on pipes twelve inches or more in diameter may be cut off in a lathe, and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than twelve per cent. of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than eleven feet in length, exclusive of the socket.

In case the length of a pipe differs from twelve feet, the standard weight of the pipe given in Table No. 2 shall be modified in accordance therewith.

Special Castings.

SECT. 5. All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The diameters of the sockets and the external diameters of the spigot ends of the special castings shall not vary from the standard dimensions by more than .08 of an inch for castings 16 inches or less in diameter; .10 of an inch for 18-inch, 20-inch, and 24-inch pipes; .13 of an inch for 30-inch, 36-inch, and 42-inch pipes, and .16 of an inch for 48-inch, 54-inch, and 60-inch pipes.

The flanges on all manhole castings and manhole covers shall be

faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The contractor shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans, and made of the best quality of mild steel, with hexagonal heads and nuts, and sound, well-fitting threads.

Marking.

SECT. 6. Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe and special casting shall also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below; thus, —

1901	1901	1901
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall be not less than two inches in length and one-eighth of an inch in relief for pipes eight inches in diameter and larger. For smaller sizes of pipes the letters may be one inch in length. The weight and the class letter shall be conspicuously painted in white on the inside of each pipe and special casting after the coating has become hard.

Allowable Percentage of Variation in Weight.

SECT. 7. No pipe shall be accepted the weight of which shall be less than the standard weight by more than five per cent. for pipes sixteen inches or less in diameter, and four per cent. for pipes more than sixteen inches in diameter; and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than two per cent.

No special casting shall be accepted the weight of which shall be less than the standard weight by more than ten per cent. for pipes twelve inches or less in diameter and eight per cent. for larger sizes; and no excess above the standard weight of more than the above percentages for the several sizes will be paid for.

Quality of Iron.

SECT. 8. All pipes and special castings shall be made of cast iron of good quality, and of such character as shall make the metal of the castings strong, tough, and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

Tests of Material.

SECT. 9. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall for pipes 12 inches or less in diameter support a load of 1 900 pounds and show a deflection of not less than .30 of an inch before breaking, and for pipes of sizes larger than 12 inches shall support a load of 2 000 pounds and show a deflection of not less than .32 of an inch. The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

Casting of Pipes.

SECT. 10. The straight pipes shall be cast in dry sand molds in a vertical position. Pipes sixteen inches or less in diameter shall be cast with the hub end up or down, as specified in the proposal. Pipes eighteen inches or more in diameter shall be cast with the hub end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Quality of Castings.

SECT. 11. The pipes and special castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature

which, in the opinion of the engineer, unfit them for the use for which they are intended. No plugging or filling will be allowed.

Cleaning and Inspection.

SECT. 12. All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

Coating.

SECT. 13. Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300° Fahrenheit immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300° Fahrenheit (or less, if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

Hydrostatic Test.

SECT. 14. When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows : —

	20-inch Diameter and Larger. Pounds per Sq. In.	Less than 20-inch Diameter. Pounds per Sq. In.
Class A pipe..............................	150	300
Class B pipe..............................	200	300
Class C pipe..............................	250	300
Class D pipe..............................	300	300
Classes E to K pipe, inclusive	350	350

Weighing.

SECT. 15. The pipes and special castings shall be weighed for payment under the supervision of the engineer, after the application of the coal-tar pitch varnish.' If desired by the engineer, the pipes and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of two thousand pounds.

Contractor to Furnish Men and Materials.

SECT. 16. The contractor shall provide all tools, testing machines, materials, and men necessary for the required testing, inspection, and weighing at the foundry of the pipes and special castings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the transverse tests upon the test bars.

Power of the Engineer to Inspect.

SECT. 17. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without

proving, any pipe or other casting which is not in conformity with the specifications or drawings furnished.

Inspector to Report.

SECT. 18. The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection.

Castings to be Delivered Sound and Perfect.

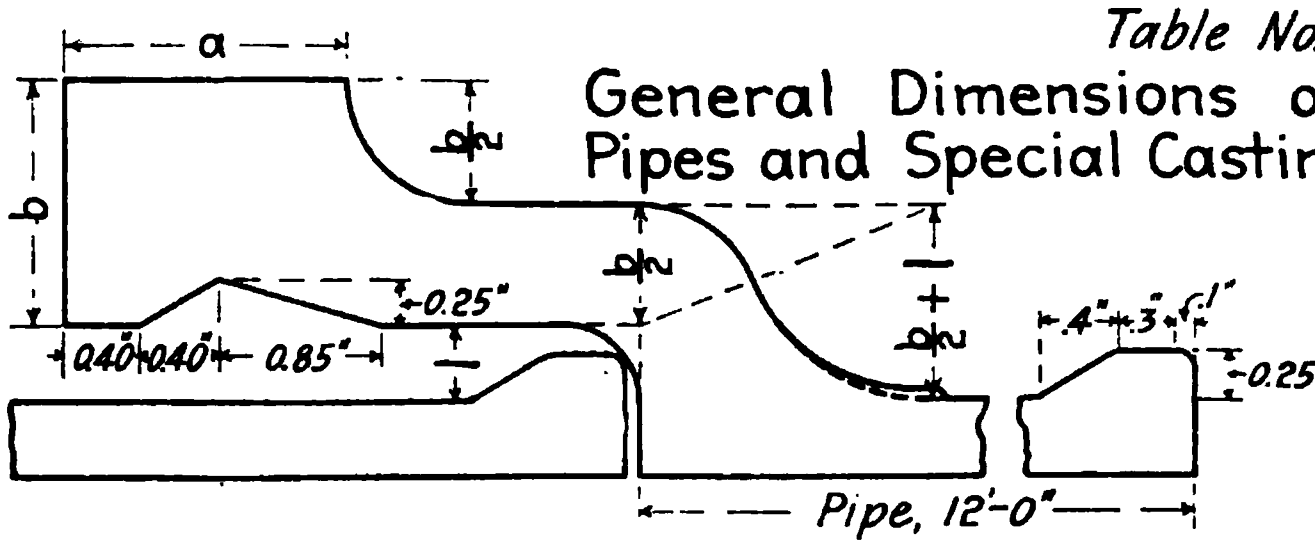
SECT. 19. All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other casting which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract, provided, however, that the contractor shall not be held liable for pipes or special castings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

Definition of the Word "Engineer."

SECT. 20. Wherever the word "engineer" is used herein, it shall be understood to refer to the engineer or inspector acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.

Table No. 1

General Dimensions of Pipes and Special Castings.



Nominal Diam. INCHES	Classes	Actual Outside Diam. INCHES	DIAM. OF SOCKETS Pipe INCHES	DIAM. OF SOCKETS Special Castings INCHES	DEPTH OF SOCKETS Pipe INCHES	DEPTH OF SOCKETS Special Castings INCHES	"a"	"b"
4	A,C,E	4.80	5.60	5.70	3.00	4.00	1.50	1.30
"	G,I,K	5.00	5.80	"	"	"	"	"
6	A,C,E	6.90	7.77	7.80	"	"	"	1.40
"	G,I	7.10	7.90	"	"	"	"	"
8	A,C,E	9.05	9.85	10.00	3.50	"	"	1.50
"	G,I	9.30	10.10	"	"	"	"	"
10	A,B,C,D	11.10	11.90	12.10	"	4.50	"	"
"	E,F,G,H	11.40	12.20	"	"	"	"	"
12	A,B,C,D	13.20	14.00	14.20	"	"	"	1.60
"	E,F,G,H	13.50	14.30	"	"	"	"	"
14	A,B,C,D	15.30	16.10	16.35	"	"	"	1.70
"	E,F,G,H	15.65	16.45	"	"	"	"	"
16	A B C D	17.40	18.40	18.60	4.00	5.00	1.75	1.80
"	E,F,G,H	17.80	18.80	"	"	"	"	"
18	A,B.	19.25	20.25	20.40	"	"	"	1.90
"	C,D	19.50	20.50	"	"	"	"	"
"	E,F	19.70	20.70	20.70	"	"	"	"
20	A,B	21.30	22.30	22.50	"	"	"	2.00
"	C,D	21.60	22.60	"	"	"	"	"
"	E,F	21.90	22.90	23.00	"	"	"	"
24	A,B	25.40	26.40	26.60	"	"	2.00	2.10
"	C,D	25.80	26.80	"	"	"	"	"
"	E,F	26.10	27.10	27.10	"	"	"	"
30	A,B	31.60	32.60	32.60	4.50	"	"	2.30
"	C,D	32.00	33.00	33.00	"	"	"	"
"	E,F	32.40	33.40	33.40	"	"	"	"
36	A,B	37.80	38.80	38.80	"	"	"	2.50
"	C,D	38.30	39.30	39.30	"	"	"	"
"	E,F	38.70	39.70	39.70	"	"	"	"
42	A,B	44.00	45.00	45.00	5.00	"	"	2.80
"	C,D	44.50	45.50	45.50	"	"	"	"
"	E,F	45.10	46.10	46.10	"	"	"	"
48	A,B	50.20	51.20	51.20	"	"	"	3.00
"	C,D	50.80	51.80	51.80	"	"	"	"
"	E,F	51.40	52.40	52.40	"	"	"	"
54	A,B	56.40	57.40	57.40	5.50	5.50	2.25	3.20
"	C,D	57.10	58.10	58.10	"	"	"	"
"	E,F	57.80	58.80	58.80	"	"	"	3.80
60	A,B	62.60	63.60	63.60	"	"	"	3.40
"	C,D	63.40	64.40	64.40	"	"	"	"
"	E,F	64.20	65.20	65.20	"	"	"	4.00

TABLE No. 2

Standard Thicknesses and Weights of Cast Iron Pipes

12 feet in length exclusive of socket

Nominal Diameter of Pipe	Class A		Class B		Class C		Class D		Class E		Class F		Class G		Class H		Class I		Class K	
	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length	Thickness of Shell	Weight per Length
	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS	INCHES	POUNDS
4	.34	200			.36	215			.39	230			.42	250			.45	265	.48	280
6	.38	330			.42	350			.46	380			.50	420			.54	445		
8	.42	475			.48	530			.53	575			.58	640			.63	690		
10	.47	650	.50	680	.53	720	.56	760	.60	810	.63	850	.67	890	.70	935				
12	.49	810	.53	855	.57	910	.61	970	.65	1040	.69	1100	.73	1160	.77	1220				
14	.53	1010	.57	1080	.61	1150	.66	1220	.70	1310	.75	1390	.79	1460	.83	1530				
16	.55	1215	.60	1300	.65	1390	.70	1490	.75	1610	.80	1710	.85	1810	.90	1900				
18	.57	1400	.63	1520	.69	1660	.75	1780	.80	1910	.86	2040								
20	.60	1610	.66	1760	.72	1920	.79	2090	.85	2260	.92	2420								
24	.64	2050	72	2290	.80	2550	.88	2780	.95	3000	1.03	3240								
30	.71	2860	.81	3230	.91	3600	1.01	3950	1.10	4340	1.20	4700								
36	.79	3800	.90	4270	1.02	4840	1.13	5310	1.25	5900	1.37	6400								
42	.87	4920	1.00	5560	1.13	6270	1.27	6970	1.40	7720	1.53	8360								
48	.95	6130	1.10	6970	1.25	7920	1.40	8780	1.55	9740	1.70	10600								
54	1.03	7510	1.20	8600	1.37	9800	1.54	10900	1.72	12400	1.90	13500								
60	1.10	8900	1.30	10300	1.50	11900	1.70	13300	1.90	15100	2.10	16500								

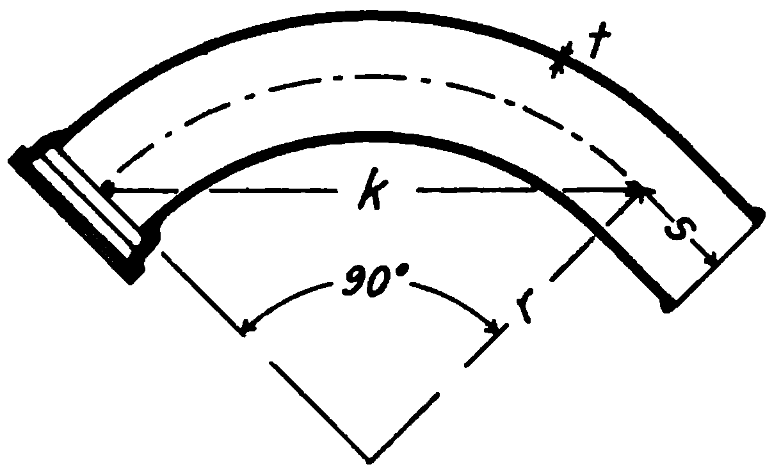
Table No. 3

Straight Pipes
Standard Weights per foot
(exclusive of sockets)

Nominal Diam.	Class	Weight per foot in lbs.	Nominal Diam.	Class	Weight per foot in lbs.	Nominal Diam.	Class	Weight per foot in lbs.
4	A	14.89	14	C	87.97	30	C	277.7
"	C	15.70	"	D	94.85	"	D	307.3
"	E	16.92	"	E	102.73	"	E	338.0
"	G	18.89	"	F	109.70	"	F	367.5
"	I	20.10	"	G	115.24	36	A	287.0
"	K	21.30	"	H	120.74	"	B	326.0
6	A	24.32	16	A	90.98	"	C	373.3
"	C	26.72	"	B	98.95	"	D	412.3
"	E	29.08	"	C	106.9	"	E	459.6
"	G	32.40	"	D	114.8	"	F	502.0
"	I	34.79	"	E	125.5	42	A	368.4
8	A	35.58	"	F	133.5	"	B	422.1
"	C	40.38	"	G	141.4	"	C	481.1
"	E	44.33	"	H	149.3	"	D	538.9
"	G	49.65	18	A	104.5	"	E	600.6
"	I	53.62	"	B	115.2	"	F	654.4
10	A	49.04	"	C	127.4	48	A	459.3
"	B	52.03	"	D	138.0	"	B	530.2
"	C	54.99	"	E	148.4	"	C	608.0
"	D	57.94	"	F	159.0	"	D	678.9
"	E	63.61	20	A	121.9	"	E	758.5
"	F	66.61	"	B	133.7	"	F	829.4
"	G	70.57	"	C	147.6	54	A	559.8
"	H	73.53	"	D	161.4	"	B	650.3
12	A	61.14	"	E	175.6	"	C	749.5
"	B	65.92	"	F	189.5	"	D	839.9
"	C	70.67	24	A	155.6	"	E	946.9
"	D	75.39	"	B	174.4	"	F	1042.7
"	E	81.99	"	C	196.3	60	A	664.0
"	F	86.77	"	D	215.3	"	B	782.3
"	G	91.51	"	E	234.5	"	C	911.5
"	H	96.22	"	F	253.5	"	D	1029.7
14	A	76.85	30	A	215.3	"	E	1162.0
"	B	82.41	"	B	244.8	"	F	1280.0

Table No. 4

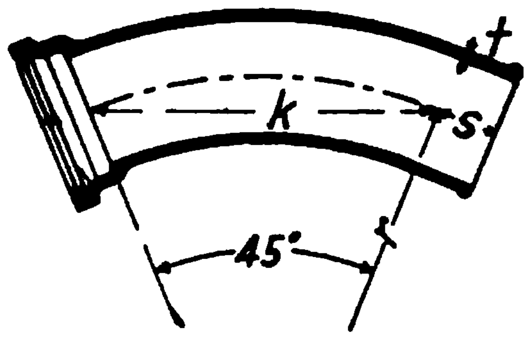
¼ Curves



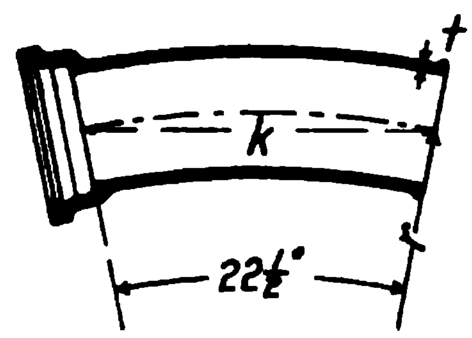
Nominal Diam.	Class	Dimensions in inches				Weight	
		t	r	k	s		
4	K	48	16	22.6	8	80	
6	I	54	"	"	"	130	
8	"	.63	"	"	10	200	
10	H	.70	"	"	12	290	
12	"	.77	"	"	"	375	
14	"	.83	18	25.5	"	500	
16	"	.90	24	34.0	"	740	
18	D	.75	"	"	"	715	
"	F	.86	"	"	"	805	
20	D	79	"	"	"	835	
"	F	.92	"	"	"	950	
24	D	.88	30	42.4	"	1275	
"	F	1.03	"	"	"	1470	
30	B	.81	36	50.9	"	1690	
"	D	1.01	"	"	"	2050	
"	F	1.20	"	"	"	2400	
36	B	.90	48	67.9	"	2750	
"	D	1.13	"	"	"	3380	
"	F	1.37	"	"	"	4040	

Table No. 5

$\frac{1}{8}$ Curves

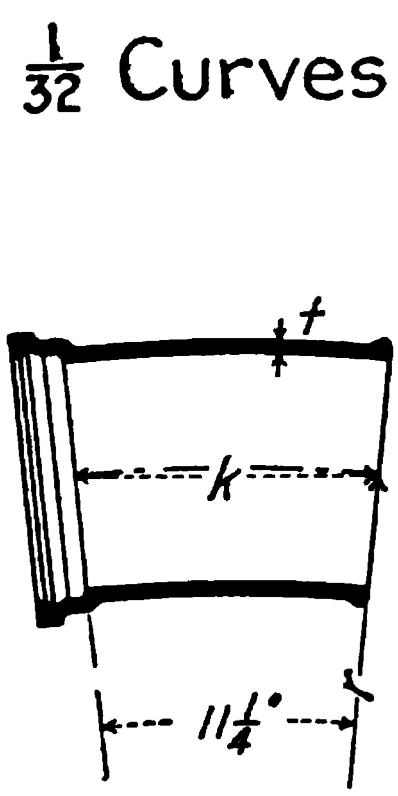


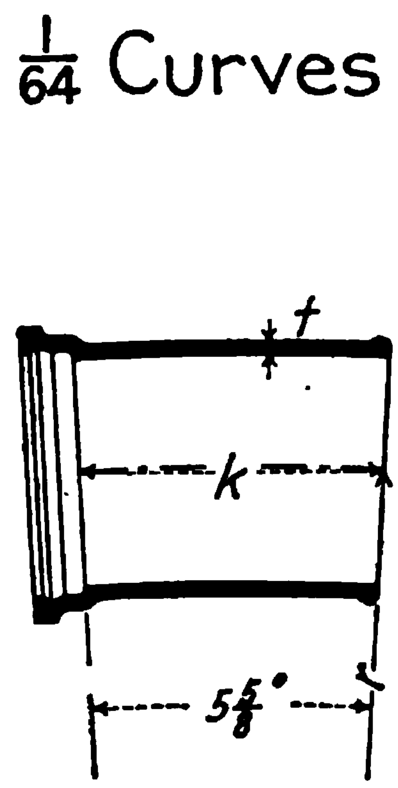
$\frac{1}{16}$ Curves



Nominal Diam.	Class	t	$\frac{1}{8}$ Curves				$\frac{1}{16}$ Curves		
			r	k	s	Weight	r	k	Weight
4	K	.48	24	18.4	4	65	48	18.7	55
6	I	.54	"	"	"	100	"	"	90
8	"	.63	"	"	"	150	"	"	130
10	H	.70	"	"	"	200	"	"	175
12	"	.77	"	"	"	260	"	"	225
14	"	.83	36	27.6		375	72	28.1	375
16	"	.90	"	"		475	"	"	475
18	D	.75	"	"		470	"	"	470
"	F	.86	"	"		520	"	"	520
20	D	.79	48	36.7		675	96	37.5	675
"	F	.92	"	"		765	"	"	765
24	D	.88	60	45.9		1060	120	46.8	1060
"	F	1.03	"	"		1210	"	"	1210
30	B	.81	"	"		1250	"	"	1250
"	D	1.01	"	"		1500	"	"	1500
"	F	1.20	"	"		1740	"	"	1740
36	B	.90	90	68.9		2300	180	70.2	2300
"	D	1.13	"	"		2810	"	"	2810
"	F	1.37	"	"		3350	"	"	3350
42	B	1.00	"	"		2980	"	"	2980
"	D	1.27	"	"		3680	"	"	3680
"	F	1.53	"	"		4370	"	"	4370
48	B	1.10	"	"		3740	"	"	3740
"	D	1.40	"	"		4620	"	"	4620
"	F	1.70	"	"		5510	"	"	5510
54	B	1.20	"	"		4630	"	"	4630
"	D	1.54	"	"		5750	"	"	5750
"	F	1.90	"	"		7170	"	"	7170
60	B	1.30	"	"		5550	"	"	5550
"	D	1.70	"	"		7020	"	"	7020
"	F	2.10	"	"		8720	"	"	8720

Table No. 6

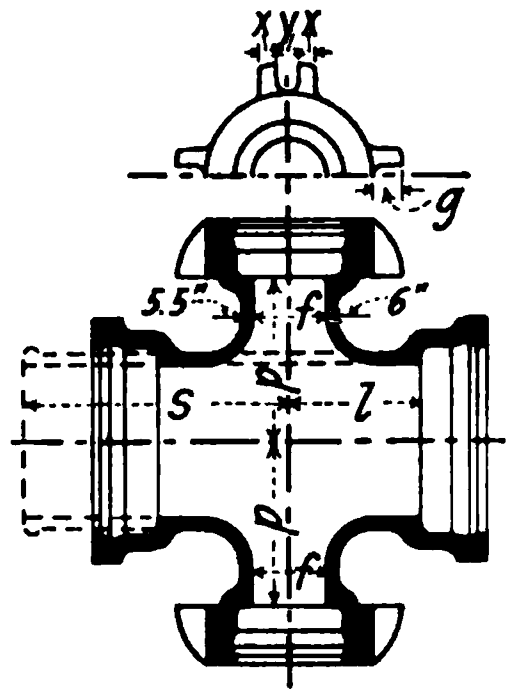




Nominal Diam.	Class	t	1/32 Curves			1/64 Curves		
			r	k	Weight	r	k	Weight
20	D	.72	240	47.05	750	480	47.10	750
"	F	.92	"	"	920	"	"	920
24	D	.88	"	"	1060	"	"	1060
"	F	1.03	"	"	1215	"	"	1215
30	B	.81	"	"	1250	"	"	1250
"	D	1.01	"	"	1500	"	"	1500
"	F	1.20	"	"	1740	"	"	1740
36	B	.90	"	"	1660	"	"	1660
"	D	1.13	"	"	2000	"	"	2000
"	F	1.37	"	"	2360	"	"	2360
42	B	1.00	"	"	2150	"	"	2150
"	D	1.27	"	"	2620	"	"	2620
"	F	1.53	"	"	3080	"	"	3080
48	B	1.10	"	"	2700	"	"	2700
"	D	1.40	"	"	3300	"	"	3300
"	F	1.70	"	"	3900	"	"	3900
54	B	1.20	"	"	3350	"	"	3350
"	D	1.54	"	"	4110	"	"	4110
"	F	1.90	"	"	5100	"	"	5100
60	B	1.30	"	"	4000	"	"	4000
"	D	1.70	"	"	5000	"	"	5000
"	F	2.10	"	"	6200	"	"	6200

Table No. 7

Branches



Dimensions in Inches									Weight			
Nom. Diam.	f	l	s	p	x	y	g	Class	3 way Branch 2 bells	3 way Branch 3 bells	4 way Branch 3 bells	4 way Branch 4 bells
4	4	11	23	11				K	125	130	155	160
6	"	12	24	12				I	170	170	205	205
"	6	"	"	"				"	190	190	240	240
8	4	13	25	13				"	250	240	285	275
"	6	"	"	"				"	275	260	325	310
"	8	"	"	"				"	290	280	370	360
10	4	14	26	14				H	340	325	375	360
"	6	"	"	"				"	360	340	410	390
"	8	"	"	"				"	380	360	450	435
"	10	"	"	"				"	405	390	505	490
12	4	15	27	15				"	450	425	490	460
"	6	"	"	"				"	470	440	510	485
"	8	"	"	"				"	485	460	555.	530
"	10	"	"	"				"	510	490	605	575
"	12	"	"	"	1.25	1.62	2.50	"	570	540	710	680
14	4	16	28	16				"	570	540	610	580
"	6	"	"	"				"	590	560	635	605
"	8	"	"	"				"	610	580	675	645
"	10	"	"	"				"	630	600	720	690
"	12	"	"	"	"	"	"	"	685	655	825	795
"	14	"	"	"	"	"	"	"	715	685	895	860
16	4	17	29	17				"	735	705	770	740
"	6	"	"	"				"	750	715	790	760
"	8	"	"	"				"	765	735	830	800
"	10	"	"	"				"	790	760	875	845
"	12	"	"	"	"	"	"	"	835	805	975	945
"	14	"	"	"	"	"	"	"	865	835	1040	1010
"	16	"	"	"	"	"	"	"	935	905	1170	1140
18	4	18	30	18				D	725	730	760	760
"	"	"	"	"				F	810	795	845	825
"	6	"	"	"				D	745	745	790	790
"	"	"	"	"				F	830	810	875	860
"	8	"	"	"				D	765	765	830	830

Table No. 7
(continued)

Branches

Dimensions in Inches									Weight			
									3 way Branch		4 way Branch	
Nom. Diam.	f	l	s	p	x	y	g	Class	2 bells	3 bells	3 bells	4 bells
18	8	18	30	18				F	850	830	915	895
"	10	"	"	"				D	785	785	875	880
"	"	"	"	"				F	870	850	955	940
"	12	"	"	"	1.25	1.62	2.50	D	845	845	990	990
"	"	"	"	"	"	"	"	F	925	905	1070	1050
"	14	"	"	"	"	"	"	D	875	875	1050	1060
"	"	"	"	"	"	"	"	F	955	935	1130	1110
"	16	"	"	"	"	"	"	D	945	945	1200	1200
"	"	"	"	"	"	"	"	F	1020	1010	1260	1250
"	18	"	"	"	"	"	"	D	945	945	1200	1200
"	"	"	"	"	"	"	"	F	1040	1030	1310	1290
20	6	19	31	19				D	895	895	935	935
"	"	"	"	"				F	1010	990	1055	1030
"	8	"	"	"				D	905	905	975	975
"	"	"	"	"				F	1030	1010	1090	1070
"	10	"	"	"				D	935	935	1020	1020
"	"	"	"	"				F	1050	1025	1135	1110
"	12	"	"	"	"	"	"	D	975	975	1110	1110
"	"	"	"	"	"	"	"	F	1090	1070	1220	1200
"	14	"	"	"	"	"	"	D	1005	1005	1170	1170
"	"	"	"	"	"	"	"	F	1120	1100	1280	1255
"	16	"	"	"	"	"	"	D	1055	1055	1260	1260
"	"	"	"	"	"	"	"	F	1185	1160	1400	1375
"	18	"	"	"	"	"	"	D	1080	1090	1330	1330
"	"	"	"	"	"	"	"	F	1220	1190	1470	1450
"	20	"	"	"	"	"	"	D	1125	1125	1400	1400
"	"	"	"	"	"	"	"	F	1260	1235	1560	1535
24	6	21	33	21				D	1240	1230	1280	1270
"	"	"	"	"				F	1410	1370	1460	1420
"	8	"	"	"				D	1250	1240	1310	1300
"	"	"	"	"				F	1430	1390	1490	1450
"	10	"	"	"				D	1280	1270	1360	1360
"	"	"	"	"				F	1450	1410	1520	1490
"	12	"	"	"	"	"	"	D	1320	1310	1450	1450
"	"	"	"	"	"	"	"	F	1490	1450	1610	1580
"	14	"	"	"	"	"	"	D	1350	1340	1510	1500
"	"	"	"	"	"	"	"	F	1510	1470	1660	1630
"	16	"	"	"	"	"	"	D	1410	1400	1630	1620
"	"	"	"	"	"	"	"	F	1570	1530	1780	1740
"	18	"	"	"	"	"	"	D	1420	1410	1650	1640
"	"	"	"	"	"	"	"	F	1600	1550	1830	1790
"	20	"	"	"	"	"	"	D	1460	1450	1720	1710
"	"	"	"	"	"	"	"	F	1650	1610	1920	1880

Table No. 7
(continued)

Branches

Dimensions in Inches									Weight			
									3 way Branch		4 way Branch	
Nom. Diam.	f	l	s	p	x	y	g	Class	2 bells	3 bells	3 bells	4 bells
24	24	21	33	21	1.25	1.62	2.50	D	1530	1520	1870	1860
"	"	"	"	"	"	"	"	F	1730	1690	2090	2040
30	12	15	27	24	"	"	"	B	1280	1310	1400	1440
"	"	"	"	"	"	"	"	D	1500	1480	1630	1610
"	"	"	"	"	"	"	"	F	1710	1630	1830	1750
"	14	16	28	"	"	"	"	B	1350	1380	1490	1530
"	"	"	"	"	"	"	"	D	1580	1560	1740	1710
"	"	"	"	"	"	"	"	F	1790	1720	1930	1860
"	16	17	29	"	"	"	"	B	1450	1480	1640	1680
"	"	"	"	"	"	"	"	D	1690	1670	1890	1870
"	"	"	"	"	"	"	"	F	1910	1830	2100	2020
"	18	18	32	"	"	"	"	B	1530	1520	1750	1740
"	"	"	"	"	"	"	"	D	1790	1720	2010	1940
"	"	"	"	"	"	"	"	F	2060	1920	2280	2140
"	20	19	34	"	"	"	"	B	1630	1610	1870	1850
"	"	"	"	"	"	"	"	D	1910	1820	2150	2060
"	"	"	"	"	"	"	"	F	2180	2020	2440	2280
"	24	21	36	"	"	"	"	B	1770	1750	2070	2050
"	"	"	"	"	"	"	"	D	2080	1980	2390	2290
"	"	"	"	"	"	"	"	F	2380	2220	2700	2540
"	30	24	41	"	1.50	2.00	3.00	B	2070	2010	2510	2450
"	"	"	"	"	"	"	"	D	2430	2280	2890	2750
"	"	"	"	"	"	"	"	F	2780	2560	3240	3010
36	12	15	27	27	1.25	1.62	2.50	B	1650	1700	1760	1800
"	"	"	"	"	"	"	"	D	1960	1920	2070	2030
"	"	"	"	"	"	"	"	F	2270	2150	2370	2260
"	14	16	28	"	"	"	"	B	1730	1770	1870	1910
"	"	"	"	"	"	"	"	D	2050	2010	2190	2150
"	"	"	"	"	"	"	"	F	2370	2260	2500	2390
"	16	17	29	"	"	"	"	B	1840	1880	2020	2060
"	"	"	"	"	"	"	"	D	2170	2130	2360	2320
"	"	"	"	"	"	"	"	F	2510	2400	2680	2570
"	18	18	32	"	"	"	"	B	1940	1930	2150	2140
"	"	"	"	"	"	"	"	D	2310	2200	2520	2410
"	"	"	"	"	"	"	"	F	2690	2500	2900	2690
"	20	19	34	"	"	"	"	B	2070	2030	2290	2250
"	"	"	"	"	"	"	"	D	2450	2310	2670	2530
"	"	"	"	"	"	"	"	F	2860	2620	3090	2850
"	24	21	36	"	"	"	"	B	2230	2190	2500	2470
"	"	"	"	"	"	"	"	D	2640	2500	2920	2780
"	"	"	"	"	"	"	"	F	3080	2840	3370	3130
"	30	24	41	"	1.50	2.00	3.00	B	2570	2470	2970	2870
"	"	"	"	"	"	"	"	D	3040	2830	3450	3240

Table No. 7 (continued)

Branches

Dimensions in Inches									Weight			
									3 way Branch		4 way Branch	
Nom. Diam.	f	l	s	p	x	y	g	Class	2 bells	3 bells	3 bells	4 bells
36	30	24	41	27	1.50	2.00	3.00	F	3550	3220	3940	3720
"	36	27	44	"	"	"	"	B	2860	2770	3390	3290
"	"	"	"	"	"	"	"	D	3390	3180	3940	3730
"	"	"	"	"	"	"	"	F	3970	3630	4550	4210
42	12	15	27	30	1.25	1.62	2.50	B	2110	2170	2220	2280
"	"	"	"	"	"	"	"	D	2520	2470	2630	2580
"	"	"	"	"	"	"	"	F	2920	2780	3020	2880
"	14	16	28	"	"	"	"	B	2200	2260	2330	2390
"	"	"	"	"	"	"	"	D	2630	2580	2760	2710
"	"	"	"	"	"	"	"	F	3050	2910	3160	3020
"	16	17	29	"	"	"	"	B	2330	2390	2510	2570
"	"	"	"	"	"	"	"	D	2780	2730	2960	2910
"	"	"	"	"	"	"	"	F	3200	3060	3370	3230
"	18	18	32	"	"	"	"	B	2450	2450	2650	2650
"	"	"	"	"	"	"	"	D	2940	2810	3140	3000
"	"	"	"	"	"	"	"	F	3430	3160	3620	3350
"	20	19	34	"	"	"	"	B	2600	2570	2820	2780
"	"	"	"	"	"	"	"	D	3120	2940	3330	3150
"	"	"	"	"	"	"	"	F	3630	3320	3840	3530
"	24	21	36	"	"	"	"	B	2800	2760	3050	3010
"	"	"	"	"	"	"	"	D	3350	3170	3600	3420
"	"	"	"	"	"	"	"	F	3900	3590	4150	3840
"	30	24	41	"	1.50	2.00	3.00	B	3180	3070	3540	3430
"	"	"	"	"	"	"	"	D	3820	3550	4180	3910
"	"	"	"	"	"	"	"	F	4460	4030	4840	4410
"	36	27	44	"	"	"	"	B	3510	3400	3980	3870
"	"	"	"	"	"	"	"	D	4210	3950	4700	4430
"	"	"	"	"	"	"	"	F	4900	4480	5400	4970
"	42	30	47	"	"	"	"	B	3930	3810	4610	4490
"	"	"	"	"	"	"	"	D	4700	4430	5420	5140
"	"	"	"	"	"	"	"	F	5480	5050	6200	5780
48	16	17	29	33	1.25	1.62	2.50	B	2850	2920	3040	3100
"	"	"	"	"	"	"	"	D	3420	3350	3600	3530
"	"	"	"	"	"	"	"	F	4000	3790	4150	3940
"	18	18	32	"	"	"	"	B	3020	3000	3210	3190
"	"	"	"	"	"	"	"	D	3640	3450	3820	3640
"	"	"	"	"	"	"	"	F	4260	3910	4440	4090
"	20	19	34	"	"	"	"	B	3180	3120	3390	3320
"	"	"	"	"	"	"	"	D	3840	3600	4040	3800
"	"	"	"	"	"	"	"	F	4520	4100	4710	4300
"	24	21	36	"	"	"	"	B	3400	3340	3650	3590
"	"	"	"	"	"	"	"	D	4110	3870	4350	4110
"	"	"	"	"	"	"	"	F	4830	4420	5060	4650

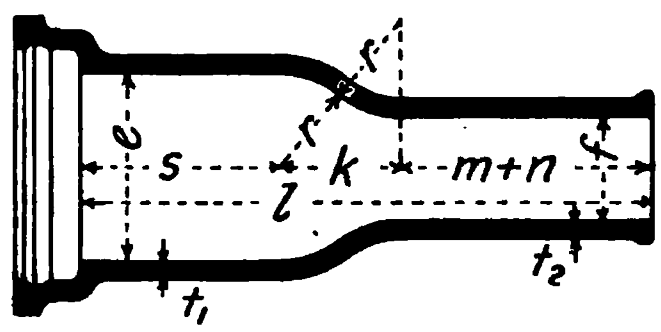
Table No. 7
(concluded)

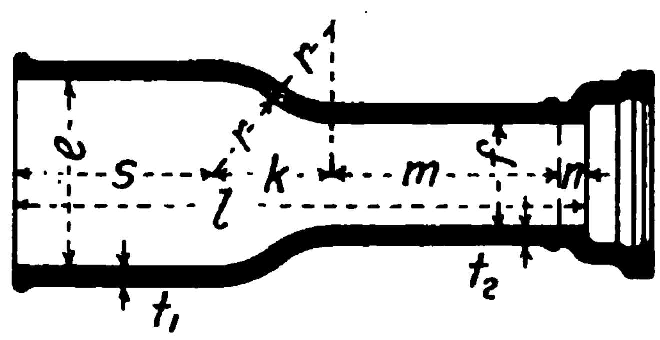
Branches

Dimensions in Inches									Weight			
									3 way Branch		4 way Branch	
Nom. Diam	f	l	s	p	x	y	g	Class	2 bells	3 bells	3 bells	4 bells
48	30	24	41	33	1.50	2.00	3.00	B	3850	3700	4200	4050
"	"	"	"	"	"	"	"	D	4650	4300	5000	4650
"	"	"	"	"	"	"	"	F	5480	4930	5810	5250
"	36	27	44	"	"	"	"	B	4210	4060	4640	4490
"	"	"	"	"	"	"	"	D	5100	4750	5510	5160
"	"	"	"	"	"	"	"	F	6000	5440	6410	5850
"	42	30	48	"	"	"	"	B	4720	4520	5310	5120
"	"	"	"	"	"	"	"	D	5680	5280	6300	5900
"	"	"	"	"	"	"	"	F	6670	6040	7280	6650
"	48	33	50	"	"	"	"	B	5100	4950	5870	5720
"	"	"	"	"	"	"	"	D	6150	5800	6950	6600
"	"	"	"	"	"	"	"	F	7220	6670	8050	7490

Table No. 11

Reducers.–Type I

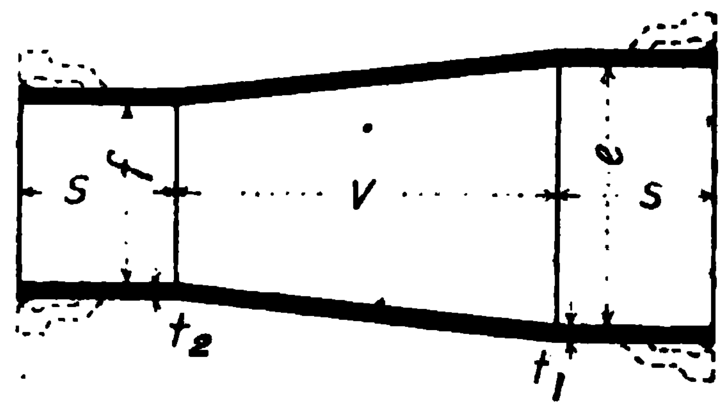




Dimensions in Inches											Weight	
Nom. diam.		s	k	m	n	l	r	t_1	t_2	Class	Bell on Large end	Bell on Small end
e	f											
6	4	10	3.3	14.7	2	30	3	.54	.48	I	100	90
8	"	"	5.3	12.7	"	"	4	.63	"	"	135	110
"	6	"	3.9	14.1	"	"	"	"	.54	"	150	140
10	4	"	7.1	10.9	"	"	5	.70	.48	H	175	140
"	6	"	6.0	12.0	"	"	"	"	.54	"	190	165
"	8	"	4.4	13.6	"	"	"	"	.63	"	215	200
12	6	"	7.9	10.1	"	"	6	77	.54	"	235	195
"	8	"	6.6	11.4	"	"	"	"	.63	"	255	230
"	10	"	4.8	13.2	"	"	"	"	.70	"	285	270

Table No. 12

Reducers - Type 2



Dimensions in Inches							Weight		
Nom. Diam. e	Nom. Diam. f	V	s	t_1	t_2	Class	Spigot ends	Bell on Large end	Bell on Small end
14	6	20	8	83	.54	H	230	275	250
"	8	"	"	"	.63	"	260	305	285
"	10	"	"	"	.70	"	290	335	320
"	12	"	"	"	.77	"	330	370	365
16	6	"	"	90	.54	"	270	330	290
"	8	"	"	"	63	"	300	360	330
"	10	"	"	"	.70	"	335	390	365
"	12	"	"	"	.77	"	370	425	405
"	14	"	"	"	.83	"	410	465	450
18	8	"	"	75	.63	D	285	370	315
"	"	"	"	.86	"	F	315	390	340
"	10	"	"	.75	.70	D	320	400	350
"	"	"	"	.86	"	F	350	420	380
"	12	"	"	.75	.75	D	355	435	390
"	"	"	"	.86	.77	F	385	460	420
"	14	"	"	.75	.75	D	375	455	420
"	"	"	"	.86	.83	F	425	500	465
"	16	"	"	.75	.75	D	395	480	465
"	"	"	"	.86	.86	F	460	535	520
20	10	26	"	.79	.70	D	410	505	440
"	"	"	"	.92	"	F	455	545	485
"	12	"	"	.79	77	D	455	550	490
"	"	"	"	.92	"	F	500	585	535
"	14	"	"	.79	79	D	490	580	530
"	"	"	"	.92	83	F	545	630	590
"	16	"	"	.79	.79	D	515	610	580
"	"	"	"	.92	90	F	595	685	655
"	18	"	"	.79	75	D	530	625	610
"	"	"	"	.92	.86	F	615	700	690
24	14	"	"	.88	.83	D	590	710	635
"	"	"	"	1.03	"	F	650	760	695
"	16	"	"	.88	.88	D	640	755	695
"	"	"	"	1.03	.90	F	705	815	765
"	18	"	"	.88	.75	D	620	740	700
"	"	"	"	1.03	.86	F	725	830	800
"	20	"	"	.88	.79	D	665	785	760
"	"	"	"	1.03	.92	F	780	885	865
30	18	"	"	81	.75	B	675	855	755

Table No. 12
(continued)

Reducers.-Type 2

Dimensions in Inches							Weight		
Nom. Diam. e	Nom. Diam. f	V	S	t_1	t_2	Class	Spigot ends	Bell on Large end	Bell on Small end
30	18	26	8	1.01	.75	D	775	930	855
"	"	"	"	1.20	.86	F	910	1050	985
"	20	"	"	.81	.79	B	715	895	810
"	"	"	"	1.01	"	D	820	975	910
"	"	"	"	1.20	.92	F	970	1110	1100
"	24	"	"	.81	.81	B	780	960	940
"	"	"	"	1.01	.88	D	920	1080	1040
"	"	"	"	1.20	1.03	F	1090	1230	1200
36	20	32	"	.90	.79	B	975	1210	1070
	"	"	"	1.13	"	D	1130	1330	1220
"	"	"	"	1.37	.92	F	1360	1530	1450
"	24	"	"	.90	.88	B	1090	1320	1210
"	"	"	"	1.13	"	D	1250	1450	1370
"	"	"	"	1.37	1.03	F	1500	1670	1610
"	30	"	"	.90	.81	B	1150	1380	1330
"	"	"	"	1.13	1.01	D	1440	1640	1600
"	"	"	"	1.37	1.20	F	1740	1910	1880
42	20	"	"	1.00	.79	B	1150	1460	1250
"	"	"	"	1.27	"	D	1360	1630	1460
"	"	"	"	1.53	.92	F	1640	1860	1720
"	24	"	"	1.00	.88	B	1270	1580	1390
"	"	"	"	1.27	"	D	1490	1750	1600
"	"	"	"	1.53	1.03	F	1790	2010	1890
"	30	"	"	1.00	.81	B	1330	1640	1510
"	"	"	"	1.27	1.01	D	1690	1950	1850
"	"	"	"	1.53	1.20	F	2040	2260	2170
"	"	66	"	1.00	.81	B	2270	2580	2450
"	"	"	"	1.27	1.01	D	2870	3140	3030
"	"	"	"	1.53	1.20	F	3470	3690	3600
"	36	32	"	1.00	.90	B	1500	1810	1740
"	"	"	"	1.27	1.13	D	1910	2180	2110
"	"	"	"	1.53	1.37	F	2320	2540	2490
"	"	66	"	1.00	.90	B	2560	2870	2790
"	"	"	"	1.27	1.13	D	3250	3520	3460
"	"	"	"	1.53	1.37	F	3950	4180	4120
48	30	32	"	1.10	.81	B	1540	1920	1720
"	"	"	"	1.40	1.01	D	1950	2280	2110
"	"	"	"	1.70	1.20	F	2360	2630	2500
"	"	132	"	1.10	.81	B	4700	5090	4890
"	"	"	"	1.40	1.01	D	5970	6290	6130
"	"	"	"	1.70	1.20	F	7230	7500	7360
"	36	32	"	1.10	.90	B	1710	2090	1940
"	"	"	"	1.40	1.13	D	2180	2500	2390
"	"	"	"	1.70	1.37	F	2650	2920	2820

Table No. 12
(continued)

Reducers.–Type 2

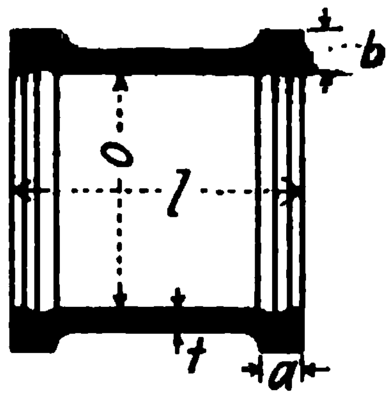
Dimensions in Inches							Weight		
Nom. Diam. e	Nom. Diam. f	V	S	t_1	t_2	Class	Spigot ends	Bell on Large end	Bell on Small end
48	36	132	8	1.10	.90	B	5250	5630	5480
"	"	"	"	1.40	1.13	D	6700	7020	6900
"	"	"	"	1.70	1.37	F	8140	8410	8310
"	42	32	"	1.10	1.00	B	1910	2290	2220
"	"	"	"	1.40	1.27	D	2440	2770	2710
"	"	"	"	1.70	1.53	F	2970	3240	3200
"	"	132	"	1.10	1.00	B	5880	6260	6190
"	"	"	"	1.40	1.27	D	7510	7840	7780
"	"	"	"	1.70	1.53	F	9140	9410	9370
54	36	66	"	1.20	.90	B	3300	3790	3530
"	"	"	"	1.54	1.13	D	4220	4630	4430
"	"	"	"	1.90	1.37	F	5200	5720	5370
"	"	132	"	1.20	.90	B	5940	6430	6170
"	"	"	"	1.54	1.13	D	7600	8010	7810
"	"	"	"	1.90	1.37	F	9360	9880	9530
"	42	66	"	1.20	1.00	B	3650	4140	3960
"	"	"	"	1.54	1.27	D	4690	5100	4960
"	"	"	"	1.90	1.53	F	5770	6290	6000
"	"	132	"	1.20	1.00	B	6580	7070	6890
"	"	"	"	1.54	1.27	D	8450	8860	8720
"	"	"	"	1.90	1.53	F	10400	10900	10600
"	48	66	"	1.20	1.10	B	4040	4530	4420
"	"	"	"	1.54	1.40	D	5200	5610	5520
"	"	"	"	1.90	1.70	F	6400	6910	6670
"	"	132	"	1.20	1.10	B	7290	7780	7670
"	"	"	"	1.54	1.40	D	9370	9780	9700
"	"	"	"	1.90	1.70	F	11550	12050	11800
60	36	66	"	1.30	.90	B	3710	4280	3940
"	"	"	"	1.70	1.13	D	4810	5280	5010
"	"	"	"	2.10	1.37	F	5940	6520	6110
"	"	132	"	1.30	.90	B	6670	7240	6900
"	"	"	"	1.70	1.13	D	8650	9120	8850
"	"	"	"	2.10	1.37	F	10680	11260	10850
"	42	66	"	1.30	1.00	B	4080	4650	4390
"	"	"	"	1.70	1.27	D	5310	5770	5570
"	"	"	"	2.10	1.53	F	6540	7110	6760
"	"	132	"	1.30	1.00	B	7340	7910	7650
"	"	"	"	1.70	1.27	D	9550	10000	9820
"	"	"	"	2.10	1.53	F	11800	12350	12000
"	48	66	"	1.30	1.10	B	4480	5040	4860
"	"	"	"	1.70	1.40	D	5820	6290	6150
"	"	"	"	2.10	1.70	F	7180	7760	7450
"	"	132	"	1.30	1.10	B	8070	8630	8450
"	"	"	"	1.70	1.40	D	10500	10950	10800

Table No. 12 (concluded)

Reducers.–Type 2

Dimensions in Inches							Weight		
Nom. Diam. e	Nom. Diam. f	v	s	t_1	t_2	Class	Spigot ends	Bell on Large end	Bell on Small end
60	48	132	8	2.10	1.70	F	12950	13500	13200
"	54	66	"	1.30	1.20	B	4900	5470	5390
"	"	"	"	1.70	1.54	D	6400	6860	6810
"	"	"	"	2.10	1.90	F	7940	8520	8460
"	"	132	"	1.30	1.20	B	8840	9400	9330
"	"	"	"	1.70	1.54	D	11550	12000	11950
"	"	"	"	2.10	1.90	F	14300	14900	14850

Table No 13



Sleeves

Dimensions in Inches							Weight
Nom. Diam.	Class	a	b	l	o	t	
4	K	1.50	1.30	10	5.8	.65	45
6	I	"	1.40	"	7.9	.70	65
8	"	"	1.50	12	10.1	.75	100
10	H	"	"	"	12.2	"	120
12	"	"	1.60	14	14.3	.80	170
14	"	"	1.70	15	16.4	.85	220
16	"	1.75	1.80	"	18.7	.90	275
18	D	"	1.90	"	20.5	.95	315
"	F	"	"	"	20.8	"	320
20	D	"	2.00	"	22.6	1.00	365
"	F	"	"	"	23.1	"	375
24	D	2.00	2.10	"	26.7	1.05	465
"	F	"	"	"	27.2	"	475
30	B	"	2.30	"	32.7	1.15	620
"	D	"	"	"	33.1	"	630
"	F	"	"	"	33.5	"	635
36	B	"	2.50	"	38.9	1.25	805
"	"	"	"	20	"	"	1010
"	D	"	"	15	39.4	"	815
"	"	"	"	20	"	"	1020
"	F	"	"	15	39.8	"	820
"	"	"	"	20	"	"	1030
42	B	"	2.80	15	45.1	1.40	1050
"	"	"	"	20	"	"	1310
"	D	"	"	15	45.6	"	1060
"	"	"	"	20	"	"	1330
"	F	"	"	15	46.2	"	1070
"	"	"	"	20	"	"	1340
48	B	"	3.00	15	51.3	1.50	1280
"	"	"	"	20	"	"	1600
"	D	"	"	15	51.9	"	1290
"	"	"	"	20	"	"	1620
"	F	"	"	15	52.5	"	1300
"	"	"	"	20	"	"	1640
54	B	2.25	3.20	15	57.5	1.60	1570
"	"	"	"	20	"	"	1960
"	D	"	"	15	58.2	"	1590
"	"	"	"	20	"	"	1980
"	F	"	3.80	15	58.9	1.90	1940
"	"	"	"	20	"	"	2410
60	B	"	3.40	15	63.7	1.70	1850
"	"	"	"	20	"	"	2300
"	D	"	"	15	64.5	"	1870
"	"	"	"	20	"	"	2330
"	F	"	4.00	15	65.3	2.00	2260
"	"	"	"	20	"	"	2810

APPENDIX.

Report of the Foundry Committee.

January 31, 1902.

Freeman C. Coffin, F. F. Forbes, Dexter Brackett, Committee on Standard Specifications for Cast-Iron Pipe, of the New England Water Works Association:

Gentlemen, — The Committee appointed by the Cast-Iron Pipe Founders desire to acknowledge the care and thoroughness with which the subject of standard specifications has been taken in hand by yourselves. In considering the papers submitted, they have viewed them, first, from the standpoint of securing good castings and such as will commend themselves to the general average of the trade, and doing this with the thought of not increasing unduly the cost of manufacturing the pipe, which cost must be in the end borne by the purchaser. They desire you to appreciate that the changes they suggest have in many instances arisen from their intimate knowledge of the business, both from the standpoint of manufacturers and also from the market requirements. They feel the reasons which have prompted them to the changes which have been made had best be discussed by a joint meeting of your Committee and the committee of the Cast-Iron Pipe Founders.

It may be well to give the reasons for departing from the suggestion of a uniform external diameter of pipe. Roughly, they are that adhering to uniform external diameters will tend to increase the cost of manufacturing, and also produce bad pipe. As to the schedule of and variation of weights, the changes in the variation of weight have been made so as to permit of cheapening production, without increasing the cost of the pipe to the buyer. It is to fully explain these and other changes that the pipe manufacturers would be glad to have a meeting with your committee.

SPECIFICATIONS

Suggested by the Foundry Committee.

DESCRIPTION OF PIPES.

The pipes shall be made with hub and spigot joints, which shall accurately conform to the dimensions given in Table No. 1. The nominal diameter shall be the actual diameter.

They shall be true circles in sections, with their inner and outer surfaces concentric.

The straight pipes shall be straight, and the curved pipes shall be true to the required curvature in the direction of their axis.

They shall be of the specified dimensions in internal diameter from end to end, and the straight pipe shall be at least twelve feet in length, exclusive of socket.

Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint room from any cause. The joint room for each class of pipe shall not vary more than .06 of an inch from the dimensions given in Table No. 1.

Pipes 16 inches or less in diameter shall be accepted when the thickness of metal in the body of the pipe is not more than .08 of an inch less at any point than the standard thickness, but for pipes over 16 inches in diameter, the variation may be .12 of an inch.

The length of the pipe shall not be changed except by written permission of the engineer, and in case of such change the standard weight of the pipe shall be modified in accordance therewith.

DEFECTIVE SPIGOTS.

Defective spigot ends on pipes may be cut off in a lathe, and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. No pipe shall be banded which is less than eleven feet in length, exclusive of the socket. That portion of the spigot end of a pipe or special casting which enters the bell shall not be picked or hammered by the inspector.

SPECIAL CASTINGS.

All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The contractor shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on the plans, with hexagonal heads and nuts, and sound, well-fitting threads.

MARKING.

Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name, the year in which it was cast, and the class letter. When cast especially to order, each pipe and special casting shall also have cast upon it the number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus, —

1901	1901	1901
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser.

The letters and figures are to be cast on the outside, not less than two inches in length and one-eighth of an inch in relief, on pipe eight inches and over; on smaller pipe size of letters to be proportionate.

PERCENTAGE TO BE PAID FOR.

No pipe shall be accepted the weight of which shall be less than the standard weight by more than five per cent. for pipes sixteen inches or less in diameter, and four per cent. for pipes more than sixteen inches in diameter; and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe the sum of the standard weights for the same number of pieces of the given size and class by more than two per cent.

No special casting shall be accepted the weight of which is more than twelve per cent. less than the standard weight, and not more than twelve per cent. in excess of the standard weight shall be paid for.

QUALITY OF IRON.

The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace. It shall be of such character as to make a pipe strong, tough, and of

even grain, and soft enough to satisfactorily admit of drilling and cutting.

Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 1 800 pounds, and show a deflection of not less than .30 of an inch before breaking. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests. The founder shall have the right to pour three bars from each ladle, and the decision of the test shall be based on the average result.

HOW CAST.

The straight pipes shall be cast in dry sand molds, in a vertical position, and the pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

QUALITY OF CASTINGS.

The pipes and castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

CLEANING AND INSPECTION.

All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection, but no pick shall be used. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

COATING.

Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit immediately before it is dipped, and shall possess not

less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahrenheit (or less if the engineer shall so order) and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

HYDROSTATIC TEST.

When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipes shall be subjected is, for

Class	A,	200	pounds per square inch.
,,	B,	250	,, ,, ,, ,,
,,	C,	300	,, ,, ,, ,,
,,	D,	300	,, ,, ,, ,,

WEIGHING.

The pipes and special castings shall be weighed for payment under the supervision of the engineer, after the application of the coal-tar pitch varnish, and the weight of each pipe and special casting shall be conspicuously painted in white on the inside, after the coating has become hard. If desired by the engineer, the pipes and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by legalized weighmaster.

CONTRACTOR TO FURNISH MEN AND MATERIALS.

The contractor shall provide all tools, materials, and men necessary for the proper testing, inspection, and weighing at the foundry of the

pipes and special castings; should the buyer have no inspector at the works the founders shall, if notified by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the transverse tests upon the test bars.

POWER OF THE ENGINEER TO INSPECT.

The engineer shall be at liberty at all times to inspect the material at the foundry, and the moulding, casting, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings furnished.

CASTINGS TO BE DELIVERED SOUND AND PERFECT.

All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other casting which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during the transportation or at any time after they receive the coating.

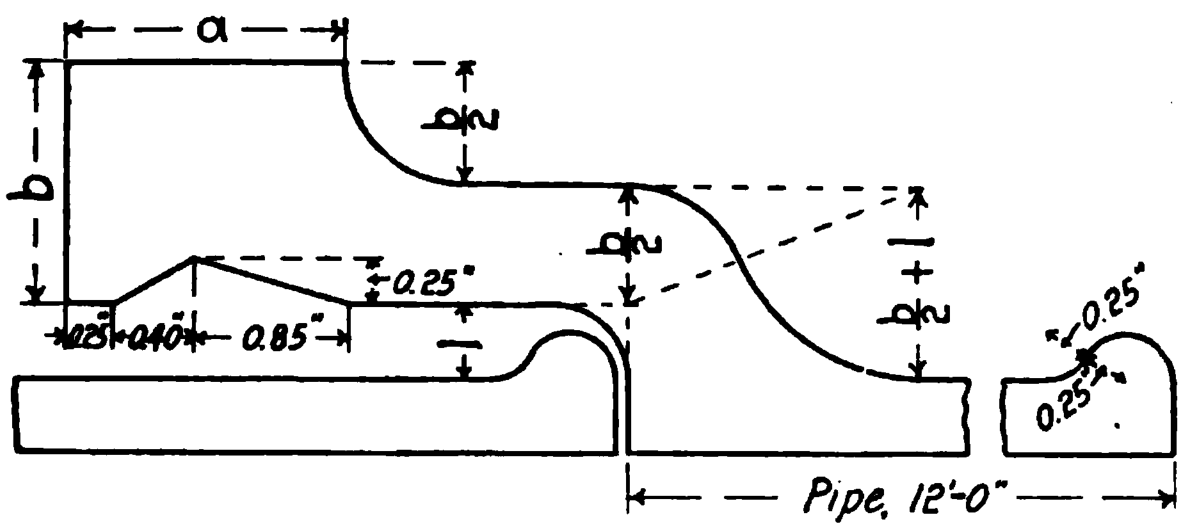
DEFINITION OF THE WORD "ENGINEER."

Wherever the word "engineer" is used herein it shall be understood to refer to the engineer, or inspector, acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them, and all such instructions by any agents must be stated in writing in order to be binding.

INSPECTORS.

All inspectors must be experienced and fully competent for the work to which they are assigned.

TABLE NO. 1.—GENERAL DIMENSIONS OF PIPES AND SPECIAL CASTINGS.



Diam. Inches.	Depth of Sockets. Pipe. Inches.	Depth of Sockets. Special Castings. Inches.	Thickness of Joint for Calking. Inches.	"a."	"b."
4	3.00	4.00	.40	1.50	1.30
6	"	"	"	"	1.40
8	3.50	"	"	"	1.50
10	"	4.50	"	"	"
12	"	"	"	"	1.60
14	"	"	"	"	1.70
16	4.00	5.00	.50	1.75	1.80
18	"	"	"	"	1.90
20	"	"	"	"	2.00
24	"	"	"	2.00	2.10
30	4.50	"	"	"	2.30
36	"	"	"	"	2.50
42	5.00	"	"	"	2.80
48	"	"	"	"	3.00

TABLE NO. 2.—STANDARD WEIGHTS AND PRESSURES.

BELL AND SPIGOT CAST-IRON PIPE.

Inside Diameter of Pipe in Inches.	Approximate Laying Length in Feet.	CLASS A. Head, 100 Feet. Pressure, 43 Pounds.			CLASS B. Head, 200 Feet. Pressure, 86 Pounds.			CLASS C. Head, 300 Feet. Pressure, 130 Pounds.			CLASS D. Head, 400 Feet. Pressure, 173 Pounds.		
		Thickness.	Weight per Foot.	Weight per Length.	Thickness.	Weight per Foot.	Weight per Length.	Thickness.	Weight per Foot.	Weight per Length.	Thickness.	Weight per Foot.	Weight per Length.
4	12	.38	18.3	220	.42	20.3	243	.45	21.7	260	.47	22.9	275
6	12	.41	28.3	340	.47	32.8	393	.51	35.5	426	.54	37.1	445
8	12	.47	42.8	513	.51	47.3	567	.56	52.0	624	.61	55.4	665
10	12	.50	57.1	685	.56	63.8	765	.62	71.0	852	.68	76.7	920
12	12	.53	72.5	870	.60	82.1	985	.68	92.5	1 110	.75	100.8	1 210
14	12	.56	89.5	1 074	.65	102.4	1 229	.73	116.6	1 399	.82	128.3	1 540
16	12	.60	107.8	1 293	.69	124.7	1 496	.79	143.6	1 723	.89	158.3	1 900
18	12	.63	127.7	1 532	.74	149.0	1 788	.85	172.1	2 065	.96	191.7	2 300
20	12	.66	149.0	1 788	.78	175.3	2 104	.91	203.7	2 444	1.03	228.3	2 740
24	12	.75	200.6	2 407	.87	233.6	2 803	1.02	274.9	3 299	1.16	306.7	3 680
30	12	.87	290.2	3 482	1.01	335.6	4 027	1.19	398.6	4 783	1.37	451.7	5 420
36	12	.98	391.6	4 699	1.14	455.0	5 460	1.36	545.3	6 543	1.58	624.2	7 490
42	12	1.10	512.3	6 147	1.28	591.7	7 100	1.54	713.6	8 563	1.79	824.2	9 800
48	12	1.25	665.2	7 982	1.41	745.5	8 946	1.71	904.8	10 857	1.99	1 045.8	12 550

DISCUSSION.

Mr. Coffin. The specifications are printed here, and perhaps you will not see a very striking difference between them and the specifications which were submitted with the preliminary report. I do not know whether you will consider it desirable to have them read or not, as they are appended here, and also the specifications suggested by the foundry committee.

The President. Can you in a few words state what the changes are, without reading them through?

Mr. Coffin. I can state some of them, I think. I have already referred to abandoning of uniform outside diameters. The Committee, I may say, did their best to retain the original form; they went into the matter very carefully and became convinced it was not a practicable thing to do so. If it had been done, either the cost of the pipe would have been very greatly increased, or there would have been a possibility or a probability of getting a good many poor pipe. It required quite a difference in the thickness of the clay of the core to make all the difference between the thickest pipe and the thinnest pipe, and the manufacturers were unanimously of the opinion — and, after going into the matter thoroughly with them, we became convinced that they were sincere — that it could not be done to the extent that we called for in the original specifications. I believe that we have retained practically all of the benefits that would have been secured by our original proposition, because in the way they are designed it is possible to use the pipe from 4 to 16 inches interchangeably; that is, the lighter weights can be used with the heavier weights in a line, and *vice versa*, and one pattern of special castings can be used for all; and the Committee feel that they have done the best that they could do, everything considered.

There were several valuable suggestions made in the discussion of the preliminary report, and the Committee have adopted a number of them. I am afraid it is going to be rather hard for me to pick these out, but I will try to do so. In compliance with the request of the manufacturers' committee, referring to Section 2 of the Specifications, the allowable variation in the diameter of pipes and sockets was increased. Whereas in the original specifications, if my memory is right, the variation was .06 of an inch for all pipes, it now reads that the diameters "shall not vary . . . more than .06 of an inch for pipes 16 inches or less in diameter; .08 of an inch for 18-inch, 20-inch, and 24-inch pipes; .10 of an inch for 30-inch,

36-inch, and 42-inch pipes, and .12 of an inch for 48-inch, 54-inch, and 60-inch pipes." That varies more in accordance with the size of the pipe than the original specifications did.

The variation in thickness was increased somewhat. I don't remember what it was originally, but it now reads that "for pipes whose standard thickness is less than one inch, the thickness of metal in the body of the pipe shall not be more than .08 of an inch less than the standard thickness, and for pipes whose standard thickness is one inch or more the variation shall not exceed .10 of an inch, except that for spaces not exceeding 8 inches in length in any direction, variations from the standard thickness of .02 of an inch in excess of the allowances above given shall be permitted." That means that if there are thin spots on the pipe covering spaces which do not exceed 8 inches in either direction, the variation in thickness may be greater than it would be for long distances. Of course we all admit that when a pipe is tapped right through for services it does not materially weaken the pipe, at least we are quite ready to do it, and it seemed to the Committee it was quite safe to admit a little more variation on small spaces than on long lengths of pipe.

In regard to defective spigots which may be cut, the original specifications provided for cutting and banding a pipe 20 inches and under to an amount equal to 6 per cent. of the total number of pipes ordered. These specifications allow spigots to be cut on pipes 12 inches and over, the size has been reduced from 20 to 12 on not more than 12 per cent. of the total number; that is, we have doubled the total number which will be accepted.

In these variations from the original specifications to meet the request of the foundries, in some cases we met altogether what they required and in some cases we met them part way; but the members of the Committee considered the matter carefully and used their own judgment, and are now ready to recommend these specifications as they stand.

There has been a change made in regard to special castings. We allowed a little more variation in the diameters of the sockets of the special castings than we did in the pipes, recognizing the fact that special castings are made in a different way, and it is impossible to make them as close to the dimension in diameter as it is the pipe, some of them being made with cores and generally made with split patterns, etc. This is a matter of foundry detail which it seemed to the Committee did not go beyond the limits of good practice.

The change in marking is something which the Committee made of its own motion. Whereas in the original specifications the class letter was to be cast on the pipe, in these it is provided that the mark shall be painted on the inside, the same as the weight. The reason for doing this was that in casting pipe it is difficult to get the first pipe cast of the exact weight, and perhaps several have to be cast before the correct weight of the class can be found. If those overrun a class or underrun it, they can be marked into another class, and the Committee could see no objection to painting the class on the inside of the pipe as well as the weight. We have also allowed the sizes of the letters on pipes less than 8 inches in diameter to be 1 inch in length, whereas before it was provided that they should be 2 inches in length. That is a practical consideration; it is out of the question, perhaps, to cast a 2-inch letter on a pipe smaller than 8 inches.

"Percentage to be paid for," — there is a slight change in that. Whereas the former specification read: "No pipe shall be accepted the weight of which shall be less than the standard weight by more than 4 per cent. for pipes 16 inches or less in diameter, 3½ per cent. for 18-inch, 20-inch, and 24-inch pipes, and 3 per cent. for pipes more than 24 inches in diameter," — that is, the percentages were 4, 3½, and 3, — it now reads that this percentage of variation either above or below the standard weight shall be not "more than 5 per cent. for pipe 16 inches or less in diameter, and 4 per cent. for pipes more than 16 inches in diameter." The requirement as to the total weight for the whole order was not changed — that still remains at two per cent.; that is, the purchaser will not pay for more than two per cent. in excess. The variation in weights of special castings was raised from 6 to 10 per cent. The object of the Committee in meeting the manufacturers' committee on these points was to avoid extra expense where it seemed it would not produce a corresponding benefit.

"Tests of Material." The Committee reduced the requirement slightly for the transverse test. It reads now: "The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall for pipes 12 inches or less in diameter support a load of 1 900 pounds and show a deflection of not less than .30 of an inch before breaking, and for pipes of sizes larger than 12 inches shall support a load of 2 000 pounds and show a deflection of not less than .32 of an inch." I believe the original specifications provided for a load of

2 000 pounds for all pipes, with a deflection of .35 of an inch. This was changed somewhat in deference to the conditions at foundries, which are perhaps a little outside of the foundries which would supply pipe for this market; that is, the Western and Southern foundries find it difficult, we are informed, to get iron which will make the proper mixture to reach the requirement we had originally made.

There is a little change in the casting of pipes. It reads now: "The straight pipes shall be cast in dry sand molds in a vertical position. Pipes 16 inches or less in diameter shall be cast with the hub end up or down, as specified in the proposal." Before it was to be as required by the engineer.

"Quality of Castings." The present specifications read: "The pipes and special castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature which, in the opinion of the engineer, unfit them for the use for which they are intended." That last clause was inserted at the request of the foundries, — or, rather, their request was that it should read, "and defects of every nature which unfit them for the use for which they are intended," and the Committee inserted the words, "in the opinion of the engineer."

I believe those are about all the sections which were changed in deference to the manufacturers' committee. There was one section put in as follows: "The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection." That seemed to be a reasonable requirement.

It is a little more difficult for me to remember the things which were put in on account of the discussion by members of the Association, for they are not so fresh in my mind. Here is one thing which was suggested in regard to the test of material: "In default of definite instructions the contractor shall make and test at least one bar from each heat or run of metal." And at the request of the manufacturers this clause was put in: "The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars."

There were some changes made in the hydrostatic test, but I really can't describe them now. And this clause was put in: "Bids shall be submitted and a final settlement made upon the basis of a ton of 2 000 pounds."

The Committee have also changed the form of the spigot ends and made a slight change in the form of the sockets, somewhat in accord-

ance with what was suggested in the discussion. By referring to the cut you will see that the bead on the spigot end is made somewhat heavier, and the socket meets the body of the pipe by a small fillet or extra thickness in the metal, shown on the cut by a dotted line. This is simply a practical detail of foundry work, as most pipe are cast that way, and the Committee thought it better to make the cut correspond with the practice. It was suggested that there should be a taper shown on the line of the socket marked "a." The Committee considered that it was the practice in all casting for the pattern-makers to make what is called a draft on the pattern, to allow the pattern to draw out of the sand, and that it was not necessary to show that on the cut. I presume that there are things which I have forgotten to state, but I have mentioned all which occur to me now.

THE PRESIDENT. I consider this report one of the most important ever submitted to this Association, and I hope there will be a full and free discussion. The report is now before you, gentlemen, for your consideration.

MR. COFFIN. One more thing I would like to speak of, Mr. President, and that is, that the table of weights of pipe, Table No. 2, was changed by omitting every other class of the sizes from 4 to 8 inches, and carrying the classes a little further on in the case of those sizes, and also in the case of pipe up to 16 inches in diameter. The original table provided up to Class F, but now 4-inch pipe go to Class K, 6- and 8-inch to Class I, and 10-, 12-, 14-, and 16-inch to Class H. This was to provide for practice where they use heavier pipe than is customary in this vicinity.

THE PRESIDENT. We shall be glad to hear from any one who is interested in this matter of standard specifications for cast-iron pipe.

MR. LEONARD METCALF.* It seems to me that the Committee has presented such an excellent set of specifications that there is not much to criticise, and without opportunity for criticism it is very hard to get up a discussion. I agree very heartily with our President that the Committee have done a work of great value to our Association and to water-works men in general.. I only hope that their work may extend a little further, and that they will give us also, as I believe they intend to do, a list of special castings which can be used in conjunction with these specifications.

MR. COFFIN. It is the intention of the Committee to prepare

* Civil Engineer, Boston, Mass.

such a list if the specifications are adopted. It will involve considerable labor and some expense, therefore the Committee concluded it was better not to undertake to do it until the matter of the specifications was finally settled.

MR. METCALF. I should like to ask Mr. Coffin if it is the idea of the Committee that it would be wiser to adopt these specifications now, or whether they think the matter had better be held open to await action on the part of any of the other associations, as, for instance, the American Water Works Association. I believe that organization is considering this matter, and I do not know but what the Committee has been in correspondence with its committee, although no allusion is made to that in the report.

MR. COFFIN. I do not know that I can answer that question for the Committee. We feel that we have done our work now, and we have presented these specifications to the Association for it to adopt or to take any action which it sees fit in regard to them. As I look at it, I think nothing would be gained by delay. I believe that if there were any important changes to be made in order to come to an agreement with other associations, perhaps they could be made afterwards as well; and I think it may be fair to say that no action will be taken by other associations until this Association takes action on these specifications. I would like, however, to hear from the other members of the Committee on this point, for I do not assume to speak for them upon this matter, as that is something which has not been discussed in the Committee.

MR. METCALF. In other words, you think that if this Association takes the initiative in this matter the other associations will fall into line.

MR. COFFIN. Yes, sir; and perhaps suggest some desirable amendments.

MR. CHARLES W. SHERMAN. On that subject, Mr. President, it may be of interest for me to say that I was looking over the report of the last convention of the American Water Works Association no longer ago than last evening, and read there the action taken by their committee on cast-iron pipe specifications. The report of that committee consists principally of a statement that our Committee is doing valuable work in this direction and a reprint of the preliminary specifications prepared by our Committee last winter, with the suggestion that those specifications, or revised specifications, would come up for final adoption at our convention in September, and a

request that any of their members who had anything further to add on the subject would forward it either to their own secretary or to ours before the date of this meeting. We having heard nothing from them up to this time I assume that we will not, and I should be inclined to think that their committee stood ready to indorse our Committee's action, and that their association will indorse what their committee recommends.

THE PRESIDENT. Your impression would be that they are waiting for the action of this convention?

MR. SHERMAN. Precisely.

MR. BRACKETT. I received, some time ago, a letter from the chairman of the committee on pipe specifications of the American Water Works Association, in which he stated that he should recommend for adoption the form of specification which was adopted by this Association.

It may be of interest to the members to hear the names of the pipe founders who have been consulted during the preparation of our report, as showing how wide a field was represented and the foundries which will be likely to accept these specifications if we adopt them. The manufacturers represented at our conferences were the United States Cast Iron Pipe and Foundry Company, which now owns and controls the cast-iron pipe plants at Burlington, N. J.; Buffalo, N. Y.; Scottdale, Pa.; Cleveland, Columbus, and Addyston, Ohio; Newport and Louisville, Ky.; Chattanooga, Bridgeport, and South Pittsburgh, Tenn.; Bessemer and Anniston, Ala., and West Superior, Wis. Messrs. R. D. Wood & Co. represented their plants at Camden and Florence, N..J.; and there were also represented the Donaldson Iron Company, Emaus, Pa.; the Warren Foundry and Machine Company's plant at Phillipsburg, N. J., and the plants at Lynchburg and Radford, Va. In all there were twenty foundries, represented by a committee which very carefully considered the specifications and consulted with us. I wish to say that the changes which have been made in the specifications since the preliminary draft was presented have been very largely the result of investigations which were made by the committee. Some of the changes, as you know, were suggested by members of the Association; some have resulted from our conferences with the manufacturers; some have been suggested to us by further study, and also by consultation with the pipe inspectors, who have, for many years, been acquainted with the best practice in the foundries, and who have given us their opinion as to the requirements necessary in order to obtain good castings.

Mr. Morris Knowles.* I am thoroughly in favor of standardization, whether it be of specifications or of statistics and accounts, but an incident that came under my observation some months ago has led me to wonder whether it will be entirely an advantage to have so many different classes of pipe. I will first tell the incident, and then I will ask a question. Something over 1 000 tons of pipe was wanted about, I think, Class C mentioned in these specifications. That does not happen to correspond with some of the standards of the Western foundries, which are heavier. After the bids were received, it was found that they were considerably in excess of the estimated cost of the work based upon standard prices current at that time for cast-iron pipe. Inquiry disclosed the fact that a certain percentage was added to the weights of pipe as they were designed, and a little increased price was charged besides that; in other words, the percentage added was not enough to bring it up to the standard of the pipe foundries in that part of the country, and therefore a little further percentage was added which, in fact, made the cost slightly more than it would have been if the standard of the various foundries had been taken. Of course, engineers desire, in specifying light weights, to save material, but if that cannot be done perhaps it is not an advantage to have so many classes. It looks, on the face of it, the manufacturers having suggested only four classes and the Committee having suggested five or more, as though possibly there might be something in their suggestion. I would, therefore, like to ask the Committee whether that matter came up in their discussions, and whether they think there is a reasonable surety that if light weights are used for certain works it will be an advantage in point of cheapness.

Mr. Coffin. I do not know that I can answer that question directly. Of course it is well known that the lighter the class the higher the price. In my own practice I have found that I could get the lighter weight cheaper, that is, for a smaller total cost, than I could get the heavier weight. But the Committee, as has been stated a number of times, felt that perhaps it was not their business, or the province of these specifications if adopted by the Association, to dictate to any engineer or any user of pipes what weights he should use; and besides that we wished the specifications to have as broad an application as possible. Now, I do know that there are engineers who are using pipe as light as anything we have provided for here,

* Civil Engineer, Pittsburg, Pa.

and perhaps in some cases lighter; and while, perhaps, no member of the Committee would use the lightest weight, still it seemed just as desirable to provide for the use of those light weights as it did on the other hand to provide for the use of the heavy weights, and then let each engineer or user select whichever he saw fit, and if his lighter weights cost him more than his heavier weights, that is his business. We recognized, however, the desirability of having as much simplicity as possible. The whole matter has been quite thoroughly considered, and while the Committee would not presume to say that they have made absolutely the best arrangement, still, in our opinion, we have done as well as possible under the circumstances.

MR. KNOWLES. Did the manufacturers' committee express any strong reasons why they recommended only four classes?

MR. COFFIN. I don't remember anything in particular. Possibly Mr. Brackett or Mr. Forbes may be able to answer that question.

MR. BRACKETT. I think it was simply this, that the manufacturer would prefer to make two classes or only one class. But as the members of the Association have expressed their desire to purchase several classes or weights of pipe, the Committee felt that it ought to endeavor to provide for their desires, and we have tried to make as few classes as will meet all reasonable demands. I understand that the Western practice is not to make smaller sizes of pipe as light as are often used in New England.

MR. E. H. GOWING.* I think Mr. Brackett has stated that about as it is, — that the pipe foundries would like to make as few classes as they possibly can. I think the specifications are good ones, they certainly have been prepared by as good men as there are in the water-works business, and I shall be very much disappointed if the Association does not adopt them. If it is proper to make such a motion at this time, I will move that the report of the Committee be accepted and that these specifications be adopted as the standard of the New England Water Works Association.

MR. G. H. BENZENBERG.† I am glad to see that the New England Water Works Association has given attention to that portion of water-works construction which heretofore has been pretty generally neglected. For the past twenty-five or thirty years particular attention has been given to those parts which are constantly visible, not only to the eye of the superintendent and operator, but also to the

* Civil Engineer, Boston, Mass. † Civil Engineer, Milwaukee, Wis.

eye of the community. The engineer and the superintendent have raised the requirements of their specifications from time to time, and the manufacturer has been willing to meet them, with the result that to-day we have pumping machinery which will develop a duty two or three times that which twenty-five or thirty years ago was supposed to be a fair average duty for pumping machinery. The distribution system of a water-works plant generally represents the largest item of cost. There is a greater sum of money invested in that branch of the works than in perhaps all the other branches taken together, and yet it has received the least attention. I dare say that only a comparatively small number of water-works managers have thought it necessary to have that branch of their work properly inspected, in order to secure compliance with the specifications, most of them accepting the pipe without inspection at the foundry. The result has been that gradually the pipe foundries have got into the habit of furnishing pipe from stock, which is undoubtedly for them the most convenient and economical arrangement.

The greater attention which has been given to boilers, pumping engines, etc., and which has resulted in supplying a much better class of machinery, was, and is undoubtedly, due to the increased economy which was obtained. It may be because the pipe distribution system is out of sight, and therefore largely out of mind, that less continuous attention has been given to its condition and to the economy which might be obtained from a better constructed and protected pipe. Nevertheless, as water-works plants are growing older, and these pipe distribution systems have been in service for a long time, examinations are being made, and it is found that they have very materially deteriorated in efficiency where soft or surface waters have been distributed, especially if the pipe was poorly prepared and indifferently coated. In some cities the standard requirements of specifications for pipe have, in recent years, been increased both as to the character of the iron and as to the method of casting, cleaning, and coating them.

Attention should be given to see, first, that the pipe is thoroughly cleaned, and it seems to me there is no better way of cleaning them than by the sand blast. By it you will remove all dirt or dust that may possibly be left upon the surface of the pipe, and the coating will then come in contact with the clean metal. The benefit of sand blasting has been very noticeable in the excellent results which have

been obtained. In draining the pipe after dipping into the bath, the coating does not peel off as it otherwise might have done at points where particles of dust or dirt had remained upon the pipe, and which points were left to corrode by the action of the water.

The coating also should receive particular attention. It has been the general custom of foundries to buy pitch from which all products of any commercial value have been extracted and which has been cut back with some dead oil, and put it in the tank for coating. The coating material should be as specifically and carefully prepared as any other article in the process of manufacture. Tests have been made to determine to what extent coal tar should be heated so as to evaporate only the lighter oils and restrain those which are beneficial to the residue as a coating for pipe. We cannot do too much in the way of studying and discussing this subject, and when we have arrived at a conclusion that it is best to raise the standard requirements in our specifications, they should then be so raised. It is for the engineer to determine, and for the contractors to furnish. The engineer should determine carefully what is required, and thereupon exact from the contractors a strict compliance with such requirements; and I haven't any doubt that when it comes to them in that form they will meet the requirements of the engineer. They may ask an increased price for it, but will not the money be as well invested as it is in higher grade machinery, and won't as full a return be secured from it? I believe that the day will come when the engineer will see the increased benefit in pipe prepared to an ideal condition, and that he will specify such, that he will specify the pipe to be enameled, coating it, perhaps, with a porcelain enamel. What would be the result? He would have to pay from fifteen to twenty per cent. more for his pipe, certainly not over twenty per cent. more than the present cost of pipe, for such improved conditions. In return he would receive a pipe having from fifteen to twenty per cent. additional conveying capacity, besides which it would be in a condition to resist all corrosive action, even that of the electric current, and which would retain its full carrying capacity, probably, for the life of cast iron so protected, the period of which I don't believe I would want to state. The benefits to be derived from such pipe, it seems to me, would, as a water-works plant increases in age, be far in excess of the additional cost which would be entailed. I don't doubt but what to-day, if properly enameled water pipe were required, some manufacturer would meet the requirement, and if he did, others would have to follow if they wished

to remain in the business. It has been so in the construction of water-works pumping machinery, and I do not see why it should not be so in every other line of manufacture required by the water-works engineer.

For these reasons it seems to me that you have not set the requirements in these specifications any too high for the foundry men to meet. I am satisfied if you will insist upon the terms of your specifications, and that even if you were to make them much more stringent, the contractor will find it to his advantage to meet them, not at the cost at which he is supplying pipe as now furnished to the market, but at an additional cost, although such an additional cost will not be in excess of the advantage gained, and need not be prohibitive. In a contest which was had with some of the largest manufacturers of pipe, where the specifications were quite rigid, the contractors tried hard to have them amended, but the engineers insisted upon the requirements, and after some delay the manufacturers met them. They asked an additional price at first for the improved character of cleaning and coating, but I understand that to-day they are furnishing just such pipe without any additional charge, as they have found it to be just as cheap to clean them properly with the sand blast and to give them a better coating.

I did not expect to take so much of your time, Mr. President, and I did not come here prepared to say anything on this subject, but it is a matter in which we are all deeply interested, and one that is well worth our giving more attention and more study to in the future than it has received at our hands in the past.

THE PRESIDENT. Mr. Benzenberg, to my knowledge, has made a careful study of this subject, and we all appreciate his having come from so great a distance to attend this convention and to address us. Does any other member of the Association wish to say anything upon the question? Mr. Hawley is called for.

MR. W. C. HAWLEY.* I can merely indorse what Mr. Benzenberg has so well said. I believe I mentioned the matter of the sand blast in my remarks on this subject a year ago, and I have backed up my opinion by embodying it in specifications, at any rate, as an alternative. I think that the matter of coating is one which demands attention. It has received some attention, and some improvement has been made in that direction, but I believe that there is room for more. There is one matter which perhaps is

* Superintendent and Engineer, Pennsylvania Water Co., Wilkinsburg, Pa.

a little out of line, and yet it will follow immediately upon the adoption of such a set of specifications as has been presented, to which I would like to refer, and that is the importance of securing the enforcement of them.

In a case that came to my knowledge not long ago, a set of specifications was prepared, calling for certain material and certain results, and specifically stating certain conditions which would result in the rejection of the pipe, and a contract was awarded. A considerable quantity of the pipe was cast, and the inspector, who was a first-class man, a practical foundryman, and a man of perfect integrity, rejected practically all the pipe which he inspected. The engineer looked into the case and found that the inspector was perfectly right in rejecting the pipe under the specifications, and yet the contractor insisted that the pipe must be accepted, basing his insistence upon the claim that they were "commercial castings," as he termed it. That case is not yet settled. The pipe were not accepted, and the municipality was put to a very large expense, and the controversy will finally be threshed out in the courts. The municipality intends, I believe, to have it determined whether or not it has any rights which a contractor is bound to respect.

Now, that is what we find ourselves up against oftentimes when it comes to the enforcement of such specifications as these, and it is a matter which deserves the careful consideration of every superintendent and engineer.

MR. BRACKETT. Mr. President, I do not know as I care to prolong the discussion, but I wish to say that I am very heartily in accord with the statements made by the last two speakers. I think there are many specifications for water pipe that contain provisions which are impracticable and which are therefore not enforced by the inspectors. I have discovered this during my visits to the pipe foundries during the past twenty years and from constant association with inpectors. I think, however, that the requirements of our proposed specifications can be enforced by an inspector, and that good work will be the result of such enforcement. I should be very glad to see a better protective coating and better cleaning of the pipe, and I think the time is coming when we shall have them. There is no reason why any member of this Association should not improve on these specifications, but for general practice it seems to me that the Committee has gone about as far as it is practicable to go at this present time. Some pipes for my own work are now being cleaned

by the sand blast and coated with what may be an improved coating, although time alone will decide. A number of years ago I made huite an extensive series of experiments for the purpose of obtaining a better coating than was then used upon pipes, but was not able to find anything at that time which I thought was practicable to use.

The President. If there are any representatives of pipe foundries present, we hope they will not be bashful about speaking on this subject.

Mr. Robert S. Weston. I should like to ask the Committee if they considered the desirability of incorporating in the specifications anything in regard to the chemical constituents of the iron; that is, that there should not be more or less than a certain amount of carbon and different things of that character, as is customary in specifications for iron for some kinds of structural work.

Mr. Coffin. The Committee did consider that, and also a great many other things to which no reference has yet been made. I was very much interested in the discussion by Mr. Benzenberg, and by some of the other speakers, and it has suggested something to my mind which I wanted to speak of. I will say, to begin with, that I believe it has been the endeavor of the Committee to prepare specifications which would represent a high average practice; that is, if these specifications are followed, the pipe that is furnished will, in my opinion, be very much superior to the pipe that is furnished and used to-day, not, perhaps, by the Metropolitan Water Board, not by large cities and by the ablest engineers, but throughout the cities and towns where pipe is bought and used as it is to-day, necessarily, a great deal of it, without the advice of any engineer. I believe that if these specifications are adopted and enforced, very much superior pipe will be obtained in such cases. If these specifications are adopted by this and other associations, such action will undoubtedly result in their adoption by the foundries.

Now, in relation to higher requirements, I will say that that matter was considered, and it seemed to the Committee that those might be regarded as in the nature of pioneer requirements; for instance, the sand blast, superior methods of coating and chemical requirements, and all those things which can be readily asked for by any engineer, in addition to the requirements of these specifications. These specifications, perhaps, may be considered as a groundwork, a basis, and any refinements which may be desirable — and all this

pioneer work is desirable and necessary — can be introduced in addition, but it did not seem best to include them in a set of standard specifications which it is hoped will cover a wide range of practice.

Then another point which has been raised, is as to the enforcement of these specifications. I should like to say that to make them of any value, it is of the utmost importance, if they are adopted by the Association and favored by the members, for us all to see that when we buy pipe the provisions of the specifications are carried out, so far as we can do so; because if we simply order the pipe, and say that it must conform to the specifications of the New England Water Works Association, and then pay no more attention to the matter, we shall get the same pipe that we are getting to-day without specification. But I believe, as I have said before, that if these specifications are adopted and enforced, we shall get in a majority of cases very much better pipe than we have had in the past.

MR. EDWARD V. FRENCH. I understand that this question of the number of classes has already been discussed to a considerable extent by members of the Association, but Mr. Knowles has brought the matter up again and I should like to ask whether, if members of the Association would like to have these specifications become the standard, it would not perhaps help them to win their way with the practical foundrymen if there were fewer classes. It seems to me as if the difference is so small that if we could get down to a few classes the foundrymen would make those regularly, and then if an engineer should desire to shade those classes on his own best judgment he could do so. Perhaps I may not understand the matter aright, but my point is this, that when we have so many classes the different superintendents and users of pipe may order first one class and then another, perhaps without any very great reason for their selection and distinction between the very small differences, with the result that the foundrymen will be a good deal bothered by these small shades of difference; and I wondered whether in the long run we could not get right down to three or four sizes which would represent good average practical conditions for the large majority of work, and then let the engineer, who is the man ordinarily to decide on these small differences, order any special size he wants, the specifications which the Association puts out representing something a little bit simpler.

MR. GOWING. Mr. President, I think the Committee has got this down simple enough, and that really instead of shading these specifi-

cations at all they should be made more strict rather than less strict. As some of the previous speakers have said, let us make the specifications as we think they ought to be, and the foundrymen will live up to them. Just as they have done as to other kinds of machinery, they will do as to cast-iron pipe. Let us make the specifications such as they ought to be, specify what we want to get, and see that we get it, and in a short time the foundrymen will be making pipe just exactly as we want it, and by and by we can add the sand blast and all these other things.

MR. FRENCH. Mr. President, if I may say just one word more, I think the gentleman does not quite get my point. I have no doubt that we can get just what we want if we know what that is; but the question is whether from a commercial standpoint there is any real gain in splitting the thing up so fine that the foundrymen have to carry all these different sizes, and whether we are not really making it cost us more than it would if we would let them come right down to three or four sizes and put all their energies right on to those. It is not a question of making our specifications better or more strict; that has nothing to do with it. It is just a question of commercial expediency. Now, I have no interest in the foundries, but as a general proposition I think it is true that in any kind of specifications for standard work the fewer the number of requirements the better. Of course if the commercial demands require so many sizes, all right, — that is something I don't know about, — but apparently this matter of the number of classes has not yet been satisfactorily settled in every one's mind, judging by what has been said here, and therefore I have ventured to bring it up again.

MR. JOHN C. WHITNEY.* As a matter of fact, Mr. President, it seems to me that these proposed specifications really simplify things for the foundrymen. As it has been in the past each water works of any size has had its own particular form of specifications, and the foundry people have been asked to bid on these special patterns which have been provided. Now, it seems to me that with these specifications the thing will be brought down to possibly five or six classes, and I should think that the foundrymen would really want a standard such as this is.

MR. BRACKETT. The gentleman suggested having three or four classes. For sizes as high as ten inches there are only five classes, — there is one additional class on the 4-inch, but I think it would be

* Water Commissioner, Newton, Mass.

very seldom used, — and on classes above 10-inch the foundries seldom carry pipe in stock, so that the pipes would be made on orders in any case.

Mr. Benzenberg. These classes, it must be borne in mind, cannot be adhered to for all time to come. Changes in the thickness of pipe will necessarily be made as the quality of material is improved. The higher the grade of metal used, the thinner the shell of the pipe necessary to resist the strain. Undoubtedly during the past few years the quality of the metal has been much improved upon, and as I think it will be recognized that the limit has not yet been reached, these improvements will continue for years to come, and, necessarily, the thickness of the pipe will have to change. There is no necessity of wasting material by putting as much of the improved material into a pipe as was required to meet a certain strain with the old material, when you can do it with perhaps two thirds or three quarters of the former thickness of the shell. It seems to me for that reason that these classes which specify the various thicknesses can be modified before very long anyway, — just as soon as the foundries use a better quality of iron. They are now using a grade of iron with a tensile strength of from 24 000 to 28 000 pounds, whereas, perhaps only a few years back, the tensile strength was 16 000 to 18 000 pounds, and naturally the shell does not need to be so thick now as formerly. That is the distinction, as I understand, in these specifications, and they won't be likely to hold very long anyhow.

Mr. Gowing's motion to accept the report of the Committee and to adopt the specifications as the standard of the New England Water Works Association, was put and unanimously adopted.

Mr. Sherman. It seems to me it is not out of place at this time to suggest a vote of thanks to the Committee which has rendered us such able, and, I might say, distinguished service, and I therefore move that the thanks of the Association be given to Mr. Coffin and to Mr. Brackett and to Mr. Forbes.

Mr. Brackett. Mr. President, as one member of the Committee I wish to say that I feel I have only done my duty as a member of the Association, and I do not think that the Association should pass a vote of thanks to any of its members.

Mr. Coffin. I believe that is the view of the Committee as a whole.

Mr. Sherman. I will then withdraw the motion.

The President. I think I may be permitted to say that the Association appreciates the work that this Committee has done.

PROCEEDINGS OF THE TWENTY-FIRST ANNUAL CONVENTION.

SEPTEMBER 10, 11, 12, 1902.

BOSTON, MASS.,
September 10, 11, 12, 1902.

The twenty-first annual convention of the Association was held at Boston, Mass., on Wednesday, Thursday, and Friday, September 10, 11, and 12, 1902. The headquarters of the Association during the convention were at the Hotel Brunswick, and the meetings were held in the banquet hall of the hotel.

The following members and guests were registered: —

MEMBERS.

Charles F. Allen, Francis E. Appleton, R. C. Bacot, Jr., M. N. Baker, Charles H. Baldwin, Lewis M. Bancroft, F. A. Barbour, Kenneth Allen, C. H. Bartlett, J. E. Beals, E. W. Bemis, G. H. Benzenberg, J. F. Bigelow, F. E. Bisbee, G. H. Bishop, J. W. Blackmer, W. L. Blossom, George Bowers, Dexter Brackett, E. C. Brooks, Fred Brooks, G. A. P. Bucknam, James Burnie, George Cassell, J. T. Cavanagh, G. F. Chace, E. J. Chadbourne, J. C. Chase, H. W. Clark, R. L. Cochran, W. F. Codd, F. C. Coffin, R. C. P. Coggeshall, D. W. Cole, M. F. Collins, B. I. Cook, H. A. Cook, F. H. Crandall, G. K. Crandall, J. W. Crawford, G. E. Crowell, A. W. Cuddeback, G. D. Curtis, J. M. Davis, C. E. Davis, A. O. Doane, L. S. Doten, E. R. Dyer, August Fels, B. R. Felton, C. R. Felton, J. N. Ferguson, G. W. Field, H. A. Fiske, Desmond FitzGerald, J. H. Flynn, F. F. Forbes, W. E. Foss, E. V. French, A. D. Fuller, S. De M. Gage, J. C. Gilbert, D. H. Gilderson, T. C. Gleason, A. S. Glover, W. J. Goldthwait, J. W. Goodell X. H. Goodnough, J. A. Gould, F. W. Gow, E. H. Gowing, J. W. Graham R. A. Hale, J. O. Hall, E. A. W. Hammatt, J. C. Hammond, Jr., L. M. Hastings, V. C. Hastings, L. E. Hawes, W. C. Hawley, Allen Hazen, F. W. Hodgdon, H. G. Holden, J. L. Howard, W. D. Hubbard, W. E. Johnson, E. J. Johnson, E. W. Kent, Willard Kent, Patrick Kieran, F. C. Kimball, Horace Kingman, Morris Knowles, C. F. Knowlton, E. S. Larned, R. S. Lea, A. A. Knudson, W. F. Learned, J. W. Locke, C. S. Lord, H. A. Lord, D. B. McCarthy, F. A. McInnes, H. V. Macksey, A. D. Marble, A. E. Martin, W. E. Maybury, F. E. Merrill, Leonard Metcalf, H. A. Miller, J. T. Miller,

C. P. Moat, F. L. Northrop, P. D. O'Connell, C. B. Parker, W. W. Patch, W. Paulison, A. G. Pease, E. L. Peene, J. H. Perkins, T. F. Richardson, W. W. Robertson, P. P. Sharples, E. M. Shedd, C. W. Sherman, G. T. Staples, M. R. Sherrerd, M. A. Sinclair, H. E. Smith, J. Waldo Smith, G. H. Snell, H. T. Sparks, J. F. Sprenkel, G. A. Stacy, F. P. Stearns, N. W. Stearns, G. F. Swain, J. G. Tenney, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, S. Everett Tinkham, D. N. Tower, C. K. Walker, C. S. Warde, R. S. Weston, William Wheeler, J. C. Whitney, W. P. Whittemore, G. E. Wilde, F. I. Winslow, G. E. Winslow, E. T. Wiswall, L. R. Woods, E. P. Walters, C. J. Youngren. — 157.

HONORARY MEMBER.

F. W. Shepperd. — 1.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Barr Pumping Engine Co., by J. O. Cheever; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Chadwick-Boston Lead Co., by A. H. Brodrick and C. N. Fairbairn; Chapman Valve Mfg. Co., by E. G. Howard and Edward F. Hughes; Charles A. Claflin & Co., by Charles A. Claflin; Coffin Valve Co., by H. L. Weston; Wm. V. Briggs; Garlock Packing Co., by Horace A. Hart; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden, and F. C. Hersey, Jr.; International Steam Pump Co., by A. M. Pierce; Henry F. Jenks; Kennedy Valve Co., by M. J. Brosnan; Lamb & Ritchie, by Henry F. Peck; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; Charles A. Moore, by F. T. Tapley; H. Mueller Mfg. Co., by Adolph Mueller; John M. Holmes; Jenkins Bros., by H. F. Fiske, H. C. White, and J. D. Stiles; Library Bureau, by W. H. Britigan; National Meter Co., by Charles H. Baldwin, W. P. Oliver, and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey and D. B. McCarthy; Norwood Engineering Co., by H. W. Hosford; Perrin, Seamans & Co., by Charles E. Godfrey and James C. Campbell; Pittsburg Meter Co., by T. C. Clifford; Rensselaer Mfg. Co., by Fred S. Bates; Edward Robinson; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by A. P. Smith and W. H. Van Winkle; Sumner & Goodwin Co., by F. D. Sumner; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by Henry C. Folger and S. D. Higley; Union Meter Co., by C. L. Brown, F. L. Northrop, and A. S. Otis; U. S. Cast Iron Pipe and Foundry Co., by Edward T. Stuart; Walworth Mfg. Co., by George E. Pickering; R. D. Wood & Co., by Charles R. Wood; A. W. Chesterton & Co., by W. H. Greenwood; Stilwell-Bierce & Smith-Vaile Co., by F. H. Hayes. — 54.

GUESTS.

Michael Walsh (Water Commissioner), Yonkers, N. Y.; Mrs. W. H. Van Winkle, East Orange, N. J.; Mrs. T. C. Clifford, East Pittsburg, Pa.; S. B. Read, *Engineering News*, Boston, Mass.; Mrs. Helen M. Hawley and Mrs. Mary Stewart Miller, Wilkinsburg, Pa.; Mrs. Washington Paulison, Passaic,

N. J.; James P. Bacon, Cambridge, Mass.; George H. Partridge, *Engineering Record*, Boston, Mass.; Mrs. Adolph Mueller and Master William Everett Mueller, Decatur, Ill.; Mrs. Willard Kent, Narragansett Pier, R. I.; Edgar W. McCormack, Cuba; Fred C. Gifford and Hon. Murray D. Clement, Waltham, Mass.; Henry Eaton, Waltham, Mass.; John C. DeMello, New Bedford, Mass.; W. F. Whitman, Dedham, Mass.; Mrs. E. C. Brooks, Cambridge, Mass.; Herbert E. Whuttle, Knoxville, Tenn.; R. R. Swisher, Addison, Ohio; Mrs. F. N. Connet, Providence, R. I.; Mrs. W. H. Thomas, Hingham, Mass.; G. S. Walker, Dorchester, Mass.; C. T. Hawley and Miss Fannie L. Billings, Cambridge, N. Y.; E. L. Arundel, Frank L. Weaver, H. C. Taft (Members Water Board), Lowell, Mass.; R. A. Thayer, Woonsocket, R. I.; E. C. Gerrish, Tewksbury, Mass.; Mrs. George Bowers and Miss Ellen M. Weaver, Lowell, Mass.; Mrs. Lenor H. Knowlton, Miss A. M. Nightingale, Miss M. L. Gavin, Quincy, Mass.; Mrs. C. E. Davis, Upper Montclair, N. J.; Mrs. A. A. Knudson, New York City; Miss Helen F. Esmond and Mrs. D. B. McCarthy, Waterford, N. Y.; John Anderson, Binghamton, N. Y.; A. F. Hall, Marlboro, Mass.; Mrs. Charles S. Warde, Staten Island, N. Y.; Mrs. A. G. Pease, Spencer, Mass.; Mrs. C. W. Houghton, Boston, Mass.; Mrs. F. A. Houghton, Belmont, Mass.; Mr. M. C. Hyde, Springfield, Mass.; Mr. C. H. Allen, Boston, Mass.; Horace Ropes, South Framingham, Mass.; L. S. Cole, Kingston, Mass.; Fred A. Beals, Everett, Mass.; S. M. Spencer, Malden, Mass.; George A. Sanborn, William M. Collins, Lawrence, Mass.; Joseph T. Swan, Everett, Mass.; S. G. Johnson, Newton, Mass.; F. E. Hunter, W. F. Upham, and Miss J. M. Ham, West Newton, Mass.; Charles F. Merrill, Fred M. Hutchinson, Marion Merrill, W. E. Whitney, G. W. Snow, E. A. Binney, J. A. Durell, J. C. Taylor, Charles E. Childs, Fred S. Young, R. J. O'Malley, Thomas McNeill, and Harry Van Idinsture, Somerville, Mass.; H. B. Thoms, Mrs. James C. Campbell, F. A. Morrison, C. B. Moore, Edward W. Howe, Edward M. Hartwell, Mrs. J. D. Stiles, F. E. Lenaue, Boston, Mass.; James A. Bailey, Jr., Member Metropolitan Water and Sewerage Board, Arlington, Mass.; G. A. Winsor, Division Engineer, Metropolitan Water Works, South Framingham, Mass. — 82.

RECAPITULATION.

Members	157
Honorary Member	1
Representatives of Associates	54
Guests	82
	294
Counted twice	3
Total attendance	291

WEDNESDAY, SEPTEMBER 10.

The convention was called to order at 11 A.M., by President Merrill, who said: —

The hour appointed for this meeting has now arrived, and I have to announce the opening of the twenty-first annual convention of the New England Water Works Association.

We expected to have the pleasure this morning of listening to an address by his Honor Mayor Collins, but word has been received from him that it will be impossible for him to be with us, and we shall therefore be deprived of the pleasure which we had anticipated in listening to his remarks. I assure you, however, although I am not empowered to tender to you the customary official greeting of the city in which we are convened, that Boston extends to you a most cordial welcome, that the latchstring of hospitality is out for you in whatever direction you may wander, and that you are in the hands of friends whose endeavor it will be to see that this convention is both pleasant and profitable to you.

We have with us this morning a gentleman whom we have come to regard as a standby, and who has assisted us on numerous other occasions; I take pleasure at this time in calling upon Ex-Mayor John O. Hall, of Quincy, to say a few words to you.

Address of Welcome by Ex-Mayor John O. Hall, of Quincy.

Mr. President and Ladies and Gentlemen, Members and Friends of the New England Water Works Association: I confess I hardly know just the word to say to you at this time. I anticipated listening to the welcome of Mayor Collins, and I feel somewhat at a loss to know how to say the proper or fitting word. My only excuse for appearing before you is that I am willing and feel it my duty, as I always do, to respond to the request or command of my superiors. When our President requested me to say something this morning I hesitated at first; but thinking it might possibly relieve him somewhat of his embarrassment in the absence of the mayor, I consented to spend a few moments in trying to voice, if I might, something of the thoughts and feelings which fill our minds as we are here assembled.

Certainly Boston has for you, I know, a gracious welcome, and if the duties of its chief official do not permit him to be present to express it, I think you will be sure before the week ends that Boston does welcome you and that you will find, wherever you may go, she offers you every inducement and every encouragement to be bright and merry. I know how difficult it is sometimes when we meet in an assembly like this to throw off the labors and responsibilities and

burdens of life. We can come together for conference, we can grasp the glad hand, but back of it all and over it all there still rest the responsibilities of life, public and private, social and mercenary. But for a little while, at any rate, let us try to draw the curtain over all that, and for the present to enjoy ourselves to the limit; and I assure you that so far as I am personally concerned it will be my duty and pleasure, so far as I am able, to assist in every way possible in promoting the enjoyment of this occasion.

To my mind the power and the benefit of these conventions cannot be overstated or overestimated; and an obligation, it seems to me, rests upon every member of the organization to participate heartily in our duties and pleasures. It is the rubbing together, it is the sense of companionship, that gives us strength for carrying the burdens of life and its duties, and in such gatherings as this many things that trouble us and perplex us are oftentimes rolled away. You know how sometimes we will wake up in the night with a deep sense of oppression because of some responsibility, and how we will lie awake, perhaps, and toss and plan and figure the thing out, but when daylight comes the perplexity is all gone and the thing does not look at all as it did in the night. It is not half as ponderous and not half the bugbear it appeared to be. And it is just the same when we come into a convention of this kind. We say we will lock up our desks and we will drop our cares for a few days anyway, and we make a file of our papers and put them out of sight and come here and meet our neighbors and friends; and we discuss and we confer, we hear of their projects, and we try to help each other out of our difficult places, and when we go back and open our desks and take out our papers and take up our work again we find that our difficulties have solved themselves, matters have all been straightened out, and the things which seemed so burdensome to us before are now disposed of with ease and dispatch. You know the statement is made that there is no friendship that is so thoroughly cemented as the friendship which is formed over the broken bread. And so, when we get together in a convention like this, it makes us glad to be alive, and it simplifies our duties and helps us in every way. I trust that this will be the result of this meeting, and that when the week closes and we are obliged to say farewell, we will say that it has been the most helpful and most enjoyable convention that the New England Water Works Association has ever held.

New Members Elected.

The Secretary read the following names of applicants for membership, who were recommended by the Executive Committee: —

For Resident Member.

H. V. Macksey, Boston, Division Superintendent, Street Department.

Edward Phillip Walters, Boston, Biologist Metropolitan Water and Sewerage Board.

Fred J. Taylor, Westboro, Chief Engineer and Superintendent of Water Works at the Westboro Insane Hospital.

William E. Johnson, West Hartford; Conn., Assistant Engineer, Hartford Water Works, and Engineer for the Board of Water Commissioners of Hartford.

For Non-Resident Member.

Joseph T. Miller, Edgewood, Pa., with Pennsylvania Water Company.

John W. Hill, Philadelphia, Pa., Chief Engineer Bureau of Filtration.

I. A. Canals, Civil Engineer, Santurce, Porto Rico, City Engineer of San Juan.

For Associate.

The Stillwell-Bierce & Smith-Vaile Co., Boston, Steam and Power Pumping Machinery, Feed-water Heaters, Water Wheels, etc.

John M. Holmes, Philadelphia, Salesman.

Jenkins Bros., Boston, Manufacturers of Jenkins Bros.' valves, pump valves, and Jenkins' "96" sheet packing and other steam specialties.

On motion of Mr. Brackett, the Secretary was directed to cast the ballot of the Association for the applicants, which he did, and they were declared elected.

The Secretary read the following communication: —

Boston, September 10, 1902.

To the Executive Committee of the New England Water Works Association.

Gentlemen, — The constitution of our Association provides for the election to honorary membership of men eminent in work connected with hy-

draulic engineering or water supply. We have among our members one who for many years has been eminent in his profession, who has been intimately connected with some of the most important questions relating to water supply which have been under consideration in the United States. I refer to Mr. Alphonse Fteley, formerly Chief Engineer of the Croton Aqueduct Commission, and for many years connected with the engineering department of the Boston Water Works.

Mr. Fteley has taken a deep interest in this Association, and although always very busy and not physically strong, he has at considerable personal inconvenience on several occasions given the Association the benefit of his long and varied experience. On account of failing health Mr. Fteley has for several years not been able to continue the practice of his profession, but I know that he still takes an interest in all questions relating to water supply as well as in this Association. I believe that the grade of honorary membership in our Association should be given only to men eminent in their profession, and I also believe that no more fitting candidate for that grade of membership can be found than Mr. Alphonse Fteley, who I suggest be elected an honorary member of the Association.

Respectfully yours,

DEXTER BRACKETT.

The Secretary stated that the letter had been considered by the Executive Committee, and that the committee had unanimously voted to recommend Mr. Fteley for honorary membership.

On motion of Mr. Robert J. Thomas, the Secretary was directed to cast the ballot of the Association in favor of the election of Mr. Fteley as an honorary member, and this having been done, he was declared elected.

The meeting then adjourned till 2 P.M.

At the afternoon session the Hon. J. O. Hall, Ex-Mayor of Quincy, Mass., read a paper entitled, "Duties of Municipalities Regarding Water Supply." It was discussed briefly by Messrs. Freeman C. Coffin and M. N. Baker.

Mr. Freeman C. Coffin, Chairman of the Committee on "Standard Specifications for Cast-Iron Pipe," submitted the report of the committee. It was discussed by Messrs. Leonard Metcalf, Charles W. Sherman, Dexter Brackett, a member of the committee, Morris Knowles, G. H. Benzenberg, W. C. Hawley, F. N. Connet, Robert S. Weston, Edward V. French, and John C. Whitney; and on motion of E. H. Gowing the report was accepted and the specifications adopted as the standard of the New England Water Works Association.

At the evening session Mr. Frederic P. Stearns, Chief Engineer of the Metropolitan Water and Sewerage Board, gave an illustrated talk on "Recent Construction on the Metropolitan Water Works"; and Mr. Horace G. Holden, Superintendent, Nashua, N. H., read a paper on "The Water Supply of Nashua, N. H."

THURSDAY, SEPTEMBER 11.

At the opening of the morning session the following named were elected members of the Association: —

Non-Resident Member.

A. A. Knudson, New York, Electrical Engineer, engaged in investigation of the effects of electrolysis upon water-piping systems.

Associates.

Wm. V. Briggs, New York, Cast-iron and Wrought-iron Pipe, Supplies, etc.

Wm. H. Greenwood, Everett, Mass., Railway, Steamship, Mill and Water-works Supplies.

A paper giving a description of a new turbidimeter, contributed by Charles Anthony, Jr., Civil Engineer, Glenview, Hereford, England, was read by Charles W. Sherman. Remarks were made upon the subject of the paper by Messrs. Allen Hazen, F. N. Connet, and C. W. Sherman.

Mr. C. W. Sherman called attention to the fact that the constitution of the Association provides that at a business meeting during the annual convention a committee shall be appointed or elected, in such manner as the meeting shall see fit, to nominate officers for the ensuing year, and moved that the President be empowered to appoint such a committee. The motion was adopted, and the President appointed Messrs. Desmond FitzGerald, F. H. Crandall, Byron I. Cook, Joseph E. Beals, and V. C. Hastings as the committee.*

Mr. H. W. Clark, Chemist, Massachusetts State Board of Health, then read a paper on "The Removal of Color and Odor from Water."

The next business was the report of the Committee on "Apportionment of Charges for Private Fire Protection and the Means of

* Mr. FitzGerald having declined to serve, the President subsequently appointed Mr. George F. Chace in his place.

Controlling the Supply Thereto." Mr. F. H. Crandall, Chairman of the committee, reported that they had been unable to agree, and submitted a brief report in behalf of Messrs. Walker, Hammond, and himself; Mr. Edward V. French submitted a report concurred in by Messrs. Cook, Fiske, and himself; and Mr. John C. Chase presented an individual report.

Mr. Washington Paulison moved that Mr. Crandall's report be received and approved by the Association. The several reports were discussed by Messrs. Allen Hazen, W. C. Hawley, Frank C. Kimball, and R. C. P. Coggeshall, and the various members of the committee elaborated their positions.

Without action upon the report, upon motion of Mr. R. J. Thomas, the convention adjourned until 2 P. M.

Upon reassembling, Mr. Fred Brooks moved that the three reports be received and printed. The motion was seconded and adopted.

Mr. F. H. Crandall moved that the Chair appoint a committee of three water-works men, residing within fifty miles of one another, and within one hundred miles of Boston, to take up the question of Private Fire Services with committees of other societies. The motion was adopted.

Subsequently, on motion of Mr. F. C. Kimball, this vote was reconsidered. Mr. Kimball then presented a motion that the President appoint a committee of three, whose duty it shall be to ask for the appointment of and to confer with similar committees from the American Water Works Association, and other kindred associations, and also with the various underwriters' associations, to agree, if possible, upon some adequate means of controlling private fire supplies acceptable to all parties concerned, including therein all questions relating to charges therefor and similar matters. Mr. Crandall having accepted this as a substitute for his original motion, it was adopted.

On motion of Mr. Thomas, the committee was honorably discharged.

Mr. Allen Hazen, Civil Engineer, New York City, read a paper entitled, "The Physical Properties of Water." Mr. R. S. Weston discussed at some length the matters suggested by the paper.

Mr. Charles W. Sherman submitted, on behalf of the Committee on Uniform Statistics, its report. Dr. E. M. Hartwell, Secretary of the Boston Statistics Department, addressed the convention upon the subject of uniform statistics, after which, on motion of Mr. F.

H. Crandall, the report of the committee was accepted and its recommendations adopted. The committee was continued.

Mr. Henry F. Jenks, of Pawtucket, submitted the following report on Exhibits: —

List of Exhibitors at the Twenty-first Annual Convention.

Harold L. Bond & Co., Water Works Supplies, Boston.
Charles A. Claflin & Co., Water Works Supplies, Boston.
Coffin Valve Company, Boston.
Garlock Packing Company, Boston.
Hersey Manufacturing Company, Meters, Boston.
Henry F. Jenks, Drinking Fountains, Pawtucket, R. I.
Lamb & Ritchie, Tin Lined Iron Pipe, Cambridge, Mass.
Lead Lined Iron Pipe Company, Wakefield, Mass.
H. Mueller Manufacturing Company, Water Works Supplies, Decatur, Ill.
National Meter Company, Meters, New York City.
Neptune Meter Company, Meters, Long Island City, N. Y.
Perrin, Seamans & Co., Water Works Supplies, Boston.
Pittsburg Meter Company, Meters, East Pittsburg, Pa.
Edward Robinson, The Wells Light, New York.
A. P. Smith Manufacturing Company, Tapping Machines, Newark, N. J.
Sumner & Goodwin Company, Water Works Supplies, Boston.
Sweet & Doyle, Vincent Valves, Boston.
Thomson Meter Company, Meters, Brooklyn, N. Y.
Union Water Meter Company, Meters, Worcester, Mass.
Walworth Manufacturing Company, Water Works Supplies, Boston.
Jenkins Brothers, Valves, Packing, etc., Boston.
N. W. Stearns, Water Filter, Roxbury, Mass.
F. W. Gow, Meter Testing Apparatus, Medford, Mass.
Stillwell-Bierce & Smith-Vaile Company, Pumps, Dayton, Ohio.
A. W. Chesterton & Co., Water Works Supplies, Boston.
Library Bureau, Card Filing Devices, Boston.

The report was accepted.

The following new members were elected: —

Resident Members.

John W. Lynch, Brookline, Engineer at Pumping Stations Boston and Metropolitan Water Works.

Harold K. Barrows, Assistant Professor of Civil Engineering at the University of Vermont, Burlington, Vt.

Associate.

Library Bureau, Boston, Makers of Card Index Systems.

THE PRESIDENT. This concludes the more formal proceedings of this convention, to-morrow being devoted to our excursion. Personally, and I think I may say in behalf of the entire official staff, I desire to thank you for the interest which you have manifested in our work by your attendance at the meetings, and for the support and encouragement which you have given your officers in the performance of their duties. If there is no other business to come before the meeting we will now adjourn.

The convention then adjourned until evening.

At the evening session, Mr. Desmond FitzGerald, Engineer Sudbury Department, Metropolitan Water Works, gave an illustrated talk on "What an Engineer Saw in Venice."

Mr. R. C. P. Coggeshall, of New Bedford, gave an historical address, "Twenty Years After: A Retrospect."

EXCURSION TO METROPOLITAN WATER WORKS.

FRIDAY, SEPTEMBER 12, 1902.

Friday, September 12, was devoted to a visit to the Wachusett Dam and North Dike, at Clinton, and the Weston Aqueduct and Reservoir in Wayland and Weston. A special train, furnished by the courtesy of the Boston & Maine Railroad Company, left the North Union Station at 8.45 A.M., and arrived at the dam at Clinton about 10 A.M. After inspecting the work at the dam, the party walked to the North Dike, a distance of about one mile, where the soil which is being stripped from the reservoir is being deposited. A short distance below the dam a tunnel and the pedestals for a viaduct on the re-location of the Central Massachusetts Railroad may be seen.

The party returned to the dam and took the train promptly at 11.40 A.M., for Wayland, where it arrived at 12.25 P.M. Lunch was served at the Town Hall in Wayland. After lunch the Association was called to order by the President, and upon motion of Mr. Coggeshall the thanks of the Association were voted to the Boston & Maine Railroad Company and to the Metropolitan Water and Sewerage

Board, for courtesies extended. At 1.30 P.M. barges were taken for a drive of about twelve miles along the line of the Weston Aqueduct. The laying of riveted steel pipe seven feet in diameter, the construction of the masonry aqueduct and of the Weston Reservoir were inspected. At the crossing of the Charles River the construction of a coffer dam, which is to be used in laying three lines of 60-inch pipes under the river, was seen. The party returned to Boston on a train leaving Auburndale at 5.45 P.M., reaching Boston at 6.12 P.M.

The program and statistics relating to the works visited are as follows: —

Commonwealth of Massachusetts.

METROPOLITAN WATER WORKS.

VISIT OF THE NEW ENGLAND WATER WORKS ASSOCIATION TO THE WACHUSETT DAM AND DIKE AND TO THE WESTON AQUEDUCT, RESERVOIR, AND PIPE LINES, FRIDAY, SEPTEMBER 12, 1902.

The forenoon program includes an inspection of the work at the Wachusett Dam, at the North Dike, and along a portion of the relocation of the Central Massachusetts Railroad in the vicinity of the dam. The party will arrive at the dam at about 10.00 A.M., and will start to walk from the dam to the North Dike at 10.30. The trip to the North Dike will extend only to the middle of the easterly portion, and the party will return without delay, reaching the dam again about 11.15.

The remaining time can be spent in examining the tunnel and other work on the relocation of the railroad a short distance below the dam, and in further inspection of the dam.

Those who wish to see the central power plant which furnishes compressed air for all operations at the dam, quarry, and tunnel, and the quarry from which stone for the dam is obtained, can do so by omitting the trip to the North Dike, and after visiting these works they may take the train at 11.50, at the platform on the Central Massachusetts Railroad just west of the power station.

The train will leave the dam promptly at 11.40 A.M.

The afternoon program includes an inspection of points of interest on the easterly half of the Weston Aqueduct and of a portion of the pipe line which is to convey water from the aqueduct to a point near Chestnut Hill Reservoir.

Opportunity will be given to inspect the laying of riveted steel pipe 7½ feet in diameter, the construction of the masonry aqueduct with special

appliances for crushing, screening, and mixing concrete at Section 11, the construction of the Weston Reservoir, the building of a coffer dam which is to be used in laying three lines of 60-inch cast-iron pipes under the Charles River, and pipe laying in the Newton Boulevard.

Statistics.

Wachusett Dam.

Length of main dam between terminal structures	850 feet.
Length of waste weir	450 feet.
Height of top of main dam above full-reservoir level	20 feet.
Maximum height of dam above rock foundation, about	206 feet.
Present height of dam above rock foundation, about	85 feet.
Maximum thickness of dam at bottom, about	185 feet.
Thickness of dam at full-reservoir level	25 feet.
Maximum depth of water above dam	129 feet.
Masonry required for dam	280 000 cu. yds.
Contractor	McArthur Brothers Company, of Chicago.
In charge of work for contractor	Winston Brothers and Locher.
Amount of contract	$1 608 635.
Date specified for completion of dam	November 15, 1904.

The air-compressing plant includes: two double Rand compressors, operated by two compound, condensing Corliss engines of 500 horse-power each.

The two Lidgerwood cableways at the dam have each a span of 1,150 feet, and a capacity of 8 tons. The easterly and westerly movable towers which support the cableways are, respectively, 60 and 90 feet in length.

North Dike.

Length on water side	2 miles.
Height to full-reservoir level at deepest place	65 feet.
Maximum width of base	1 980 feet.
Area covered by dike	143 acres.
Contents of dike	5 500 000 cu. yds.
Total length of cut-off trench	9 556 feet.
Length of cut-off trench excavated to solid rock	3 124 feet.
Length excavated to fine sand	6 432 feet.
Length of cut-off trench where sheet piling was driven	5 245 feet.

Wachusett Reservoir.

Area of watershed	118.23 sq. miles.
Elevation of water level of full reservoir above Boston city base (low tide)	395 feet.
Water surface, 4 195 acres, or	6.56 sq. miles.
Total contents	63 068 000 000 gals.
Length	8.41 miles.
Maximum width	2.05 miles.
Maximum depth	129 feet.
Average depth	46 feet.
Total length of shore, not including islands	35.4 miles.
Length of railroad flooded	6.56 miles.
Length of highways flooded	19.21 miles.

The land required for this reservoir contained 6 large mills, 8 schoolhouses, 4 churches, and about 360 dwelling-houses occupied by upwards of 1 700 people.

The buildings, vegetation, and surface soil are being removed from the reservoir. The soil has been removed from about two thirds of the area of the reservoir, and at the end of this year the area stripped will be about four fifths of the whole.

Relocation of Central Massachusetts Railroad.

The new line of the railroad is to leave the present line just west of the bridge over the New York, New Haven & Hartford Railroad at West Berlin, and it will run so as to pass over the valley of the Nashua River just below the dam, then continuing along the shore of the reservoir to the North Dike, and across the dike behind its crest to a junction with the Worcester, Nashua & Portland Division of the Boston and Maine Railroad, which it will follow to Oakdale.

There is unusually heavy work on the line of the railroad, including a tunnel 1 063 feet long on the easterly side of the Nashua River, a viaduct 917 feet long across the valley of the river, with a maximum height above the bed of the river of 132 feet, and a rock cut having a maximum depth of 60 feet on the westerly side of the river.

Weston Aqueduct.

The aqueduct, starting at the Sudbury Dam, runs easterly for a total distance of 13.44 miles, through the towns of Southboro, Framingham, Wayland, and Weston, to the high land a short distance west of the Charles River nearly opposite Norumbega Park.

For the first 3½ miles it was feasible to obtain a fall of 4 feet in 5 000, while for the remainder of the distance down to the reservoir only 1 foot in 5 000; consequently the aqueduct, although everywhere of a daily capacity of 300 000 000 gallons, is of different sizes, the upper portion being 10 feet wide by 9 feet 3 inches high, and the lower portion 13 feet 2 inches wide by 12 feet 2 inches high.

The aqueduct is constructed chiefly of concrete masonry, but the lower half has a lining of one course of brick masonry.

There are several special sections, as follows: —

Three 5-foot cast-iron pipe-lines from Sudbury Dam to head-house.

One 7½-foot riveted steel pipe-line across the Sudbury River and Happy Hollow valleys, having, respectively, lengths of 3 603 and 1 123 feet, to be supplemented in the future by two additional lines.

Five tunnels to be lined with Portland cement concrete, and having a total length of 2.30 miles.

An open channel ¼ of a mile long, in Weston, just above the reservoir.

The estimated cost of the aqueduct, including the reservoir, is about $3 200 000.

Weston Reservoir.

The Weston Reservoir and open channel leading to it have a total length of about a mile, and for this distance the masonry aqueduct will be omitted.

The lower end of the reservoir is rather more than a mile above the terminus of the aqueduct. It is constructed for the purpose of equalizing the flow of water and preventing the aqueduct from being surcharged toward its lower end.

The area of the reservoir is 60 acres, or just half that of Chestnut Hill Reservoir.

The minimum depth will be 11 feet and the maximum depth 28 feet.

The surface of the reservoir will be 200 feet above mean low water, making it 37 feet above Spot Pond and 66 feet above Chestnut Hill Reservoir.

The dam will be constructed of earth, with a core-wall of concrete masonry resting upon rock.

Drains will convey all polluted and nearly all other local water past the reservoir into the brook below it.

Supply Pipe Lines.

From the terminal chamber of the aqueduct, the water is to be distributed to different points in the Metropolitan Water District through cast-iron pipes running in different directions.

One line of pipes is now being laid through the city of Newton, much of the way through the Newton Boulevard, as far as Chestnut Hill Reservoir, where it will connect with existing pipes. This line, which is 7.4 miles long, is 60 inches in diameter from the terminal chamber to the easterly side of the Charles River, and 48 inches in diameter for the remaining distance.

November Meeting.

Hotel Brunswick, Boston,
November 12, 1902.

President Frank E. Merrill in the chair; Willard Kent, Secretary.

The following members and guests were in attendance: —

Members.

Charles H. Baldwin, L. M. Bancroft, J. E. Beals, George Bowers, Dexter Brackett, E. C. Brooks, Fred Brooks, G. F. Chace, J. C. Chase, F. C. Coffin, R. C. P. Coggeshall, L. E. Daboll, L. S. Doten, J. N. Ferguson, H. F. Gibbs, Albert S. Glover, Amos A. Gould, John O. Hall, V. C. Hastings, T. G. Hazard, Jr., H. G. Holden, Willard Kent, G. A. Kimball, L. P. Kinnicutt, C. F. Knowlton, A. E. Martin, F. E. Merrill, H. V. Macksey, F. L. Northrop, J. H. Perkins, W. W. Robertson, E. M. Shedd, C. W. Sherman, G. T.

Staples, G. A. Stacy, R. J. Thomas, H. L. Thomas, W. H. Thomas, D. N. Tower, G. W. Travis, W. H. Vaughan, R. S. Weston, G. E. Winslow. — 43.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Barr Pumping Engine Co., by William McLaughlin; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Charles A. Claflin & Co., by Charles A. Claflin; Coffin Valve Co., by H. L. Weston; A. W. Chesterton & Co., by W. H. Greenwood; Hersey Mfg. Co., by Albert S. Glover and Francis C. Hersey, Jr.; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by James C. Campbell; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by Frank L. Northrop; United States Cast Iron Pipe and Foundry Co., by W. B. Franklin. — 19.

GUESTS.

W. A. Daggett, Jr., Natick, Mass.; J. F. Gleason, Quincy, Mass.; George H. Partridge, *Engineering Record*, Boston, Mass.; Prof. Ira N. Hollis, Harvard University, Cambridge; Prof. Edward F. Miller, Massachusetts Institute of Technology, Boston. — 5.

(Names counted twice. — 3.)

The Secretary read the names of the following applicants for membership, who were recommended for election by the Executive Committee: —

For Resident Member.

George A. Sanborn, Superintendent, Essex Company, Lawrence, Mass.

Harry E. Barnard, Chemist, State Board of Health, Concord, N. H.

D. A. Heffernan, Superintendent of Water Works, Milton, Mass.

For Non-Resident Member.

Robert E. Horton, Hydrographer, U. S. G. S., Utica, N. Y.

John W. Alvord, Civil Engineer, Chicago, Ill.

David Dexter Clarke, Engineer of Water Committee, Portland, Ore.

J. H. Ince, Assistant to President, Western New York Water Co., Buffalo, N. Y.

William R. Conard, Inspector of Materials, Burlington, N. J.

R. O. Wynne-Roberts, Water Engineer to the City of Capetown, South Africa.

On motion the Secretary was directed to cast the ballot of the Association for the applicants, which he did, and they were declared elected.

A letter from Mr. Alphonse Fteley, accepting his election as honorary member, was read by the Secretary.

The President announced his appointment of Messrs. F. H. Crandell, R. J. Thomas, and Elbert Wheeler, as the Committee on Private Fire Services, in accordance with a vote passed at the convention in September.

Prof. Ira N. Hollis, of Harvard University, was introduced, and spoke on the economic use of fuel in steam plants. Prof. L. P. Kinnicutt, in discussion, spoke of the chemist's views of combustion and of some chemical methods of attaining high temperatures.

Prof. Edward F. Miller, of the Massachusetts Institute of Technology, read a paper on "The Sulphurous Anhydride Waste-heat Engine."

Adjourned.

MEETINGS OF THE EXECUTIVE COMMITTEE.

The Executive Committee met before the meeting of the Association on September 10; present, President Merrill, Messrs. Kent, Brooks, Bancroft, Hammond, Holden, Stacy, Thomas, C. W. Sherman, and Walker. Applications for membership were approved. A letter was received from Mr. Dexter Brackett, suggesting the election of Mr. Alphonse Fteley as an honorary member of the Association. It was voted that the Executive Committee recommend the election of Mr. Fteley as an honorary member.

Adjourned.

The Executive Committee met at Tremont Temple, on October 16, 1902. The question of the place for holding the November meeting was raised, and after discussion it was unanimously voted that it be at the Hotel Brunswick.

The editor, Mr. Sherman, brought up the question of a general index to the JOURNAL. He said that for more than two years he has been trying to prepare such an index, but had not yet succeeded in making much progress. It was voted that Mr. Sherman be authorized to confer with the Library Bureau regarding the preparation of such an index.

Adjourned.

The Executive Committee met at Tremont Temple, at 11.30 A.M.; present, President F. E. Merrill, Secretary Willard Kent, and Messrs. Brooks, Thomas, Holden, Bancroft, C. W. Sherman, and Stacy. Nine applications for membership were approved. The Editor, Mr. Sherman, reported the result of his conference with the Library Bureau, regarding the preparation of a general index to the JOURNAL, and it was voted that he be authorized to have such an index prepared and printed.

Adjourned.

After the meeting of the Association on November 12, the Executive Committee again came together and voted unanimously to hold all the winter meetings at the Hotel Brunswick.

Adjourned.

OBITUARY.

George A. Hotchkin, superintendent of the Bureau of Water, Rochester, N. Y., died in that city on October 6, 1902.

Mr. Hotchkin was born in Caledonia, N. Y., in 1853, but his parents removed to Rochester while he was an infant. He was educated in the Rochester schools, and fitted himself for the profession of civil engineering. In 1874 he began work on the engineering force in connection with the first conduit from Hemlock Lake, and, with the exception of three or four years spent in contracting work, had been connected with the water department of Rochester continuously since that date. He became superintendent on January 1, 1900. His long experience in the department had familarized him with all its details, and he was regarded by superiors and subordinates alike as a faithful and capable official.

He was stricken suddenly while dining at the Whist Club, in company with City Engineer Fisher, and lived but little more than an hour. He is survived by his wife.

The following resolution was adopted by the heads of the city departments: —

Death has struck down without notice our comrade and genial companion, George A. Hotchkin, superintendent of water works. It is fitting that we should voice the sentiment which we all feel, that Rochester has lost an able, honest, and efficient official and a good citizen, and we have lost a liberal-minded, kind-hearted friend. We extend to his dearly beloved wife our heartfelt sympathy in this her direst bereavement.

Mr. Hotchkin was elected a member of the New England Water Works Association on June 13, 1900.

BOOK NOTICES.

"The Municipal Year Book, 1902; Giving the Population, Assessed Valuation, Principal Officials, and Ownership of Public Utilities, also Information regarding the Water Supply, Sewerage, Street Cleaning, Street Sprinkling, Garbage, Fire and Underground Electric Service in all Incorporated Places in the United States, and in all New England Towns of 3 000 Population and Upwards by the Census of 1900. With Summaries and Editorial Discussion." Edited by M. N. Baker, Ph.B., C.E., Associate Editor of *Engineering News*, Editor of the *Manual of American Water Works*, etc. Engineering News Publishing Co., New York. $3.00.

This is indeed "an encyclopædia of municipal news and statistics." The various statistics listed in the sub-title are given briefly for each city or town in the body of the book, and, in addition, the information of most general interest is tabulated or summarized in the introduction, and so arranged as to show the extent of municipal and private ownership of the several public utilities. A table of water purification plants, showing for each municipality where the water is purified, the kind of purification, ownership of works (whether public or private), and population may be noted as an example of especial interest to Association members, and typical of the manner in which information has been summarized for ready reference and for comparison.

"The Graphical Solution of Hydraulic Problems; Treating of the Flow of Water through Pipes, in Channels and Sewers, over Weirs," etc. By Freeman C. Coffin, M. Am. Soc. C. E. Second edition, revised and enlarged. John Wiley & Sons, New York.

This valuable hand-book is already well known and generally appreciated. It contains tables and diagrams by which all the ordinary hydraulic problems may be quickly solved with explanatory text. The second edition has been enlarged by the addition of several new diagrams and a brief discussion of the flow of water in riveted steel pipes.

INDEX TO ADVERTISEMENTS.

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INDEX TO ADVERTISEMENTS (*Continued*).

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